State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources - Native Aquatic Species

Columbia Spotted Frog (*Rana luteiventris*) Statewide Monitoring Summary, 2011

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Utah Division of Wildlife Resources
1594 West North Temple
Salt Lake City, Utah
James F. Karpowitz, Director

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SPOTTED FROG SUMMARY

This report summarizes the Columbia Spotted Frog (*Rana luteiventris*) surveys and monitoring activities performed by the Utah Division of Wildlife Resources' Northern, Central, and Southern regions during the 2011 field season. Spotted frog populations are separated into three Geographic Management Units (GMUs) and ten hydrologic unit codes (HUCs) in the State of Utah. The Northern and Central regions survey activities occurred in all three GMUs (Wasatch Front, Sevier River, and West Desert). These GMUs included the following HUCs: Spanish Fork River, Utah Lake, Provo River, Jordan River, Upper Weber River, and Lower Weber River (Wasatch Front GMU); San Pitch River (Sevier River GMU); and Ibapah Valley, Snake Valley, and Tooele Valley (West Desert GMU; Report I). Monitoring units for the Southern Region (Report II) are located only in the West Desert GMU and included: Snake Valley and Tule Valley.

In general, surveys were performed statewide between 7 March and 21 June 2011. Surveys were conducted using visual encounter surveys (VES) on spotted frog egg masses. This document represents two regional reports that contain information pertaining to translocations, inventories, habitat restoration actions, and non-native species removal efforts. For consistency, reports compiled here follow a common page, table, and to a lesser degree figure layout; however, individual reports retain the authors' style and formatting structure.

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I-Northern & Central Regions Report

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Paul Thompson and Samuel McKay, Northern Region
Paula D. Trater, Utah Reclamation, Mitigation and Conservation Commission

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EXECUTIVE SUMMARY

The Utah Division of Wildlife Resources (UDWR) began large-scale monitoring of Columbia Spotted Frog (*Rana luteiventris*) populations in 1992, and several populations have now been monitored each year since 1994. The primary objective of monitoring is to document the numbers and locations of egg masses deposited at breeding sites for each population, which can be used as a measure of annual reproductive output, and as an indicator of the distribution and abundance of breeding adults. Monitoring surveys conducted during 2011 in the UDWR Central and Northern regions occurred at the breeding sites of 13 Columbia Spotted Frog populations, one of which was discovered in 2010 and monitored for the first time in 2011. Numbers of Columbia Spotted Frog egg masses detected during monitoring surveys were higher than average for nine of the 12 populations for which long-term data were available, and were higher than in any previous year of monitoring for four of these populations: the Leland Harris and Ibapah Valley populations in the West Desert, the Heber Valley population along the middle Provo River, and the Diamond Fork population in Spanish Fork Canyon. Columbia Spotted Frogs at Diamond Fork moved into habitats created during a 2009-2010 restoration project, and used a restored pond for breeding and egg deposition for the first time in 2011. Adults were found as far away as the Spanish Fork River following the breeding season, suggesting that the Diamond Fork population is currently expanding. The number of egg masses produced by the Springville population in 2011 was four times higher than in any other year during the past decade, indicating that this population is recovering from a decline that began in 2001. Of the 12 populations for which long-term monitoring data are available, only one, the Holladay Springs population in southern Utah Valley, exhibited evidence of a prolonged decline. Three egg masses were detected at Holladay Springs in 2011, which is a small fraction (< 2%) of the number of egg masses found during 1998-2000 surveys, but typical of the reproductive output documented since 2003.

Columbia Spotted Frog monitoring activities were expanded in 2011 to include sites of recently discovered populations and sites in which reintroduction (repatriation) efforts have occurred. Five Columbia Spotted Frog egg masses were found at Lower Boulder Creek where a population was discovered in the Upper Provo River drainage in 2010. Two additional breeding sites were discovered in Upper Boulder Creek (n = 16 egg masses) and Upper North Fork (n = 1 egg mass) in 2011. Columbia Spotted Frog egg masses (n = 11) were observed for the first time at Taylor's Fork - one of three repatriation sites in the Wasatch Mountains. No Columbia Spotted Frogs or egg masses were observed at the other repatriation sites.

Management activities undertaken in 2011 focused on removing non-native species likely to have a detrimental impact on Columbia Spotted Frogs. American Bullfrog (*Lithobates catesbeianus*) tadpoles were trapped at Mona Springs (in western Juab County) and Russian Olives (*Elaeagnus angustifolia*) were cleared from Columbia Spotted Frog breeding sites in the Leland Harris Spring Complex in Snake Valley (eastern Juab County). Removal of bullfrogs is an ongoing management activity at Mona Springs. Russian Olives at the Leland Harris Spring Complex were removed during the fall of

2011 as a means of preventing the displacement of native wetland vegetation and maintaining adequate sunlight penetration to ensure that shallow shoreline habitats, which are favored as egg deposition sites by Columbia Spotted Frogs, remained thermally suitable for egg incubation.

INTRODUCTION

Columbia Spotted Frog (*Rana luteiventris*) populations in Utah are currently restricted to several spring complexes and riparian wetlands along the Wasatch Front, San Pitch River corridor, and the Ibapah, Snake and Tule valleys of the West Desert. An isolated population may also persist near the town of Vernon in Tooele County, but Columbia Spotted Frogs have not been detected at this location since 2004 (Crockett et al. 2010). A combination of habitat loss, habitat fragmentation, and negative impacts caused by introductions of non-native fishes and amphibians has eliminated populations at many historic locations and has made the management and conservation of the remaining Columbia Spotted Frog populations in Utah a high priority (Bailey et al. 2006). The planning, implementation, and assessment of strategies for effectively managing these populations depends on information on changes in the distribution and abundance of Columbia Spotted Frogs. Consequently, the Utah Division of Wildlife Resources (UDWR) began monitoring most of the known populations of Columbia Spotted Frogs in 1992, and has conducted annual surveys at designated monitoring sites since 1994 (U.S. Fish and Wildlife Service 2002). Monitoring surveys take place during the breeding season, which begins in early March at some sites and extends well into May at higher elevation sites. Each survey involves searching breeding habitats for egg masses deposited by Columbia Spotted Frogs, recording the precise locations of the egg masses, and quantifying the numbers of egg masses detected as a means of assessing the size and distribution of the breeding population and the level of reproductive output at each monitoring site (Ross et al. 1994). The data obtained has been of critical importance in formulating management strategies and evaluating the success of management activities that have been carried out in accordance with the objectives of the Conservation Agreement and Strategy for Columbia Spotted Frog in the State of Utah (Bailey et al. 2006). This report presents monitoring data collected for populations of Columbia Spotted Frogs in the UDWR Central and Northern regions during 2011, examines temporal trends in the reproductive output of these populations, and discusses the data in the context of management activities and objectives.

The Conservation Agreement and Strategy for Columbia Spotted Frog in the State of Utah (Bailey et al. 2006) identifies three Geographic Management Units (GMUs) in which Columbia Spotted Frogs are found within the UDWR Central and Northern Regions: the Wasatch Front GMU, the Sevier River GMU, and the West Desert GMU. Each GMU encompasses multiple subunits (subbasins) delineated by the United States Geological Survey (USGS). Each subunit represents a drainage system and has been assigned a unique hydrologic unit code (HUC) by the USGS. The Columbia Spotted Frog populations and repatriation sites in the UDWR Central and Northern regions are found in five subunits of the Wasatch Front GMU (the Spanish Fork River, Utah Lake,

Provo River, Upper Weber River and Lower Weber River subunits), a single subunit of the Sevier River GMU (the San Pitch River Subunit), and in three subunits of the West Desert GMU (the Ibapah Valley Subunit, Hamlin-Snake valleys Subunit, and Rush-Tooele valleys Subunit). Monitoring and management activities in each GMU and subunit are presented and discussed under separate headings in this report. The Hamlin-Snake valleys Subunit is referred to at the Snake Valley Subunit for conciseness and consistency with past reports.

The two populations in the Utah Lake Subunit have been referred to in past reports as the North of Burraston and South of Burraston populations, in reference to their locations with respect to the Burraston Ponds Wildlife Management Area (WMA), near Mona in Juab County. The northern population inhabits the Mona Springs WMA and adjacent habitat to the north, and is referred to as the Mona Springs population in this report. The southern population inhabits wetland habitats in the Juab Valley that ultimately drain into the Burraston Ponds WMA, and is referred to as the Burraston Marsh population in this report.

METHODS

Population Monitoring

Locations of populations of Columbia Spotted Frogs in the UDWR Central and Northern regions are shown in Figure 1. Each of these populations was monitored during 2011, with the exception of the Vernon population (Rush-Tooele valleys Subunit) in Tooele County, which was omitted from monitoring in 2010 and 2011 due to time constraints and the fact that no Columbia Spotted Frogs or egg masses been detected during annual monitoring at Vernon since 2004. The breeding sites of these populations are found at a variety of wetland habitats, ranging from spring complexes in desert basins to riparian wetlands in mountain valley, on private, state, tribal, and federal lands (Table 1). Monitoring activities within a given subunit were scheduled using information from preliminary surveys at designated locations referred to as sentinel sites, which were visited on multiple occasions in order to detect the beginning of the breeding season and estimate when breeding activity was likely to peak for each population. These sentinel sites have been established based on data from past years of monitoring, and represent selected breeding habitats that are consistently used for egg deposition by Columbia Spotted Frogs at the beginning of each breeding season. The onset of breeding activity at a sentinel site was determined from the earliest date on which egg masses or adult frogs in amplexus were observed. When egg masses were detected during a sentinel survey, the onset of breeding was estimated based on the date and the approximate age of the oldest egg mass. For most populations, peak breeding occurs approximately 14 days after the onset of breeding activity, but populations in the Provo River Subunit of the Wasatch Front GMU typically exhibit peak breeding activity within 7-10 days after the onset of breeding (Ammon 2001; Crockett et al. 2010).

Monitoring of Columbia Spotted Frogs in the UDWR Central and Northern regions began during 8-13 March in 2011, with surveys of the Mona Springs population and two

Snake Valley populations, and continued until the last of the surveys in the higher elevation sites of the Provo River Subunit was completed on 21 June. In general, the breeding sites of each population were surveyed on three or four occasions: once during the initial period of breeding activity, one or two times during peak breeding activity, and once approximately a week after the peak of breeding activity. The Holladay Springs population was an exception. It was surveyed only once in 2011, on 19 April, due to limited resources and access issues.

The date, time, UTM coordinates (NAD83 ± 5 m), elevation, weather conditions (ambient temperature, relative humidity, wind speed and direction, and cloud cover), and water temperature were recorded at the beginning of each monitoring survey at the point where the survey began. All surveys were visual encounter surveys that involved thoroughly searching for egg masses and active amphibians in suitable breeding habitats within the survey area (Crump and Scott 1994). This required walking along the shoreline habitats and periodically wading into deeper water to inspect pockets of suitable habitat concealed from view by emergent or shoreline vegetation. When an egg mass or cluster of egg masses was detected, the number of egg masses was recorded along with the UTM coordinates, water temperature (± 0.1° C), and water depth (to the nearest cm) at the deposition site. In addition, each egg mass was assigned to one of five age/developmental categories (Table 2).

Habitat Assessment

Characteristics of 24 potential breeding habitats of Columbia Spotted Frogs in the northeastern portion of the Leland Harris Spring Complex were measured in 2010 to facilitate an evaluation of how bodies of water used as egg deposition sites by Columbia Spotted Frogs differed from bodies of water in which breeding and egg deposition do not occur. This effort was expanded in 2011 to include two prominent spring pools and three relatively distinct areas of marsh habitat on State Institutional and Trust Land (SITLA) property in the southwestern portion of the Leland Harris Spring Complex. Each of the habitat inventories on the SITLA property was conducted on 15 June 2011 and was coupled with a search for larval, juvenile, and adult Columbia Spotted Frogs. Variables recorded during a habitat inventory included the estimated surface area of the body of water (based on length and width measurements), numbers and locations of inlets and outlets, and measurements of water depth (to the nearest cm) and the depth of loosely consolidated or unconsolidated sediments at distances of 0.5 m, 1 m, 2 m, and 3 m from 10 reference points along the periphery of the shoreline. Measurements of maximum water depth, water chemistry parameters, and percent cover of submerged, emergent, and floating vegetation were also recorded as described in Grover et al. (2012). The measurements of water depth at the four progressively larger distances from the 10 points along the shoreline were used to calculate the cumulative increase in depth with increasing distance from the shore, which was used as an index of shoreline steepness.

Columbia Spotted Frog egg masses and/or larvae (tadpoles) were detected at all five of the sites at which habitat inventories were conducted in 2011. Kruskal-Wallis tests, with Bonferroni corrected Mann-Whitney pairwise comparisons, were used to evaluate

whether habitat variables measured at these five breeding sites differed significantly from habitat measurements obtained from 16 breeding sites and from eight sites in which there was no evidence of breeding in 2010. The SITLA portion of the Leland Harris Spring Complex has several large peripheral pools with deep springs at their centers. By contrast, the large pools in the northeastern portion tend to be in the interior of the spring complex and receive spring discharge through channels from springheads that are not within the pools themselves. Consequently, the 2011 data permitted an assessment of how well conclusions regarding characteristics of breeding habitats from the 2010 analysis could be extrapolated to other years and to areas with somewhat different habitat features.

Repatriation

A management strategy that has been employed in an effort to increase the number of viable Columbia Spotted Frog populations in Utah has been the release of larval and/or juvenile Columbia Spotted Frogs in suitable habitats where populations were historically present. Sites in which this practice has become established are referred to as repatriation sites. Three repatriation sites in Summit County were surveyed during the breeding season in 2011: Shady Dell (Provo River Subunit), Taylor's Fork (Upper Weber River Subunit), and the Swaner Preserve (Lower Weber River Subunit). The repatriation site at Shady Dell was established in 2007 and was supplemented with tadpoles obtained from egg masses from other Provo River populations in 2008 and 2009. The Taylor's Fork site was initially stocked with egg masses collected in the Provo River Subunit in 2008 and stocked with additional tadpoles in 2009 and 2010. The repatriation site at the Swaner Preserve was initially stocked with 731 recently metamorphosed juveniles in 2005 and was stocked with tadpoles obtained from egg masses collected in Heber Valley during 2006, 2008, 2009, and 2010 (Grover et al. 2012).

Non-native Species Control Efforts

The Columbia Spotted Frog population that is most vulnerable to being negatively impacted by non-native amphibians is the Mona Springs population, which inhabits the Mona Springs Wildlife Management Area (WMA) and adjacent private land where American Bullfrogs (*Lithobates catesbeianus*) have become common. Removal of bullfrogs from Columbia Spotted Frog habitats at the Mona Springs WMA is an ongoing management activity. Few adult bullfrogs were detected during the Columbia Spotted Frog breeding season at Mona Springs in 2011, but large numbers of bullfrog tadpoles that had overwintered at breeding sites were observed. Consequently, bullfrog removal efforts in 2011 focused on capturing and removing tadpoles before they were able to undergo metamorphosis. The first removal period occurred during 6-13 June and involved setting 40 collapsible minnow traps over periods ranging from 2.5 to 24 hours at 10 bodies of water in which bullfrog tadpoles had been observed in the Mona Springs WMA and on adjacent private property to the north. Bullfrog tadpoles were also captured and removed during Least Chub (*Iotichthys phlegethontis*) monitoring surveys, which took place on 11 and 16 August and involved deploying 52 minnow traps at eight sites for 2-4 hours. Bullfrog tadpoles that were captured during these removal efforts

were euthanized on site. Several other non-native predators with the potential to prey on one or more age classes of Columbia Spotted Frogs were also present in minnow traps that were deployed during bullfrog removal efforts and Least Chub monitoring; including Crayfish, Fathead Minnows (*Pimephales promelas*), Western Mosquitofish (*Gambusia affinis*), and Yellow Perch (*Perca flavescens*). Individuals of these species were also euthanized on site.

West Desert populations of Columbia Spotted Frogs tend to occur in habitats that have not been heavily impacted by the spread of non-native fish and amphibians, but many of these habitats have been impacted by invasive plant species. For example, Russian Olives (*Elaeagnus angustifolia*) have spread over most of the wetland habitats in the Snake Valley and have severely altered the plant communities and physical environments of some of these habitats. The Leland Harris Spring Complex of the Snake Valley (eastern Juab County) was the focus of efforts to eradicate Russian Olives at Columbia Spotted Frog breeding habitats in 2011. UDWR crews mechanically removed Russian Olives (young trees were uprooted and larger trees were cut close to the base) and treated stumps with the herbicide Garlon 3A® over much of the Leland Harris Spring Complex during 12-13 October and 15-16 December. The purpose of this project was to prevent displacement of native wetland vegetation and maintain adequate sunlight penetration to ensure that shallow shoreline habitats favored as egg deposition sites by Columbia Spotted Frogs remain thermally suitable for egg incubation. The project will be completed in 2012 and expanded to include nearby Columbia Spotted Frog habitats at Miller Springs.

Pathogen and Biosecurity Measures

Multiple populations of Columbia Spotted Frogs and other amphibians at the survey sites have tested positive for *Batrachochytrium dendrobatidis* (Crockett et al. 2009) , the fungal pathogen responsible for amphibian chytriodiomycosis. In addition, non-native gastropods, fishes, and aquatic plants are present at several of the survey sites. Concerns over the spread of pathogens, parasites, and invasive species dictated that several precautions be taken in order to minimize the chance of transferring organisms from one site to another. Following each visit to a site, all mud and debris was removed from boots and equipment, which were then treated with a 1:100 solution of Quat-128™ (a pH-neutral disinfectant containing quaternary ammonia) and allowed to dry before being used again at another site. When possible, equipment was exposed to direct sunlight for two or more days between uses to ensure thorough drying and maximize exposure to UV light.

RESULTS

Wasatch Front GMU

Provo River Subunit

Three populations of Columbia Spotted Frogs in the Provo River Subunit have been monitored on an annual basis during years prior to 2011. Two of the populations, the Heber Valley and Upper Provo River populations, are widely distributed over multiple breeding areas. The Heber Valley population occupies numerous ponds and wetlands

that were created during the Provo River Restoration Project (PRRP) along roughly 15 km of the Provo River riparian corridor between Jordanelle Reservoir and Deer Creek Reservoir in Wasatch County. The Upper Provo River population occupies an array of breeding sites on State Park, United States Forest Service (USFS), and private lands upstream from Jordanelle Reservoir along approximately 30 km of the upper Provo River riparian corridor. The third population (Wallsburg population) appears to be small and isolated, and is monitored at a single pond on private land in Wallsburg, roughly 10 km to the south of Heber Valley. During 2011, monitoring surveys of these three populations began on 16 March and continued until 7 June. The total number of egg masses detected during surveys at breeding sites of these populations was 1510, with 417 detected at Upper Provo monitoring sites, 1091 at Heber Valley, and two at Wallsburg (Table 4). The Upper Provo River population has been remarkably stable, in terms of reproductive output, during the past seven years (Figure 2). The total of 417 egg masses detected in 2011 the lowest on record, but is still only 18-19% lower than the average and median values for 2003-2011. Unusually cold weather and heavy late season snowfall delayed the onset of breeding for the Upper Provo River population in 2011, which was estimated to have begun on April 28 – approximately a month later than the average from previous years (Table 1). The 1091 egg masses detected in Heber Valley followed several years of high reproductive output beginning in 2004 (Figure 3), and represents the highest number on record (Table 4). The Wallsburg population was monitored at its only known breeding site for the fourth consecutive year in 2011. Very few egg masses (2-6 per year) have been detected at this site.

A previously unknown population of Columbia Spotted Frogs in the Provo River Subunit was discovered by U.S. Forest Service biologists in 2010 at Boulder Creek, a tributary to the North Fork of the Provo River. The presence of Columbia Spotted Frogs of all age classes at Boulder Creek was confirmed during a survey by UDWR and U.S. Forest Service biologists on 15 September 2010. The 2010 survey site (Lower Boulder Creek) was officially monitored in 2011, as were a nearby site on the North Fork of the Provo River (Upper North Fork) and a high elevation site in the Boulder Creek drainage (Upper Boulder Creek) at which beaver ponds with suitable breeding habitat had been identified using satellite imagery. The Lower Boulder Creek site was surveyed on five occasions from 19 May to 21 June during 2011. Five egg masses were detected during these surveys. The beaver ponds at the Upper Boulder Creek site were surveyed on 6 June and 21 June, resulting in the discovery of 16 egg masses. The Upper North Fork site was surveyed on 31 May, 6 June, and 21 June. A single egg mass was detected during the 31 May survey. The tadpoles from this egg mass had hatched by the time of the 21 June survey. The confirmation of breeding activity at each of the three survey sites indicates that a reasonably large population of Columbia Spotted Frogs exists along Boulder Creek and the adjacent reach of the North Fork of the Provo River.

The repatriation site in the Provo River Subunit, at Shady Dell, was surveyed for Columbia Spotted Frogs and egg masses on 1 June, 7 June, and 21 June of 2011. No Columbia Spotted Frogs or egg masses were observed. The Shady Dell site was established during the spring of 2007 and has been surveyed every year since that time. The most recent stocking of Columbia Spotted Frog tadpoles at Shady Dell occurred on

20 May 2009. Female Columbia Spotted Frogs typically require 3-6 years to reach sexual maturity (males mature 1-2 years earlier), with females from cool high elevation sites growing slower, maturing at smaller sizes, and taking longer to mature than females from lower elevation sites (Turner 1960; Licht 1975; Reaser 2000). Consequently, any surviving females from the 2009 cohort would have been too young to reproduce at the time of the 2011 surveys, and it is possible that females from the 2007 and/or 2008 cohorts were present, but had not yet reached sexual maturity.

Upper and Lower Weber River Subunits

The Taylor's Fork repatriation site in the Upper Weber River Subunit was surveyed for Columbia Spotted Frogs and egg masses on 25 May, 1 June, and 7 June of 2011. Eleven egg masses were detected during these surveys, indicating that individuals belonging to at least one cohort of translocated tadpoles had survived to sexual maturity and reproduced. Taylor's Fork was initially stocked with larval Columbia Spotted Frogs on 27 May 2008, was stocked again on 14 May 2009, and was stocked a third time on 28 May 2010. The discovery that at least some of the females stocked as tadpoles in 2008 reached sexual maturity in 2011 suggests that females from the 2009 and 2010 cohorts are likely to reach sexual maturity in 2012 and 2013. Four egg deposition sites were observed at Taylor's Fork in 2011. Two egg masses were observed at the exact location where the tadpoles had been released during the previous three years. The remaining egg masses were found downstream in beaver ponds peripheral to Beaver Creek, up to 225 m from the original stocking location.

Visual encounter surveys were conducted at the Swaner Preserve of the Lower Weber River Subunit on 2 May and 11 May in 2011. The timing of these surveys was meant to coincide with the peak of Columbia Spotted Frog breeding activity for the Upper Provo population, which is the closest population found in habitats of similar elevations to those at the Swaner Preserve. No egg masses or Columbia Spotted Frogs were observed during these surveys, despite exhaustive searches of all potential breeding habitats on the preserve. Breeding adult Columbia Spotted Frogs were present and produced egg masses at the Swaner Preserve during 2008 and 2009, but there has been no evidence of subsequent breeding activity or persistence of the population. Supplemental stocking of Columbia Spotted Frog tadpoles occurred at Swaner Preserve during 2009 and 2010, which leaves open the possibility that juveniles still present at the site may reach sexual maturity in 2012 or later.

Spanish Fork River Subunit

Monitoring of Columbia Spotted Frog populations in the Spanish Fork River Subunit in 2011 began on 17 March and continued until 21 April. The total number of egg masses observed was 254, with 170 detected at Diamond Fork, 81 detected at Springville, and three detected at Holladay Springs. The 170 egg masses detected at Diamond Fork represent the highest number detected since monitoring began there in 2003. The Springville population exhibited a period of relatively high reproductive output from 1997 through 2000, but experienced a decline from 2001 to 2009 (Figure 4). The 2010 total of 18 egg masses was the highest since 2001 and hinted at a future recovery. The 2011 total of 81 egg masses was the highest since 1998, suggesting that the population of

breeding adults has increased substantially over the past two years. The Columbia Spotted Frog population at Holladay Springs was once robust, but reproduction has been extremely limited since 2003 (Figure 4).

The distribution of Columbia Spotted Frogs and egg masses observed in the Diamond Fork area in 2011 suggests that the population is currently expanding. Egg masses were widely distributed in nearly all bodies of water in which breeding activity has been documented, and two egg masses were deposited in a pond that was excavated in 2009 as part of a habitat restoration project designed to increase the amount of suitable breeding habitat for Columbia Spotted Frogs. The 2011 breeding season was the first time that reproduction occurred within the habitat restoration area. Re-vegetation of ponds in the restoration area began in 2010 and will likely improve their potential to attract breeding Columbia Spotted Frogs in the near future. Two adult Columbia Spotted Frogs were observed near the confluence of Diamond Fork with the Spanish Fork River on 4 October 2011, indicating that the population now extends into riparian habitats beyond Diamond Fork.

Utah Lake Subunit

Monitoring of Columbia Spotted Frog populations in the Utah Lake Subunit began on 10 March in 2011 and continued until 18 April. A total of 55 egg masses were detected at Mona Springs and an additional 65 were detected to the southwest of Mona in habitats inhabited by the Burraston Marsh population of Columbia Spotted Frogs. Both populations apparently declined to low numbers in 2003 and 2004, but exhibited an increase in numbers of breeding adults from 2005 through 2010 (Figure 5). The combined total of 120 egg masses for the two sites in 2011 was similar to the 2007-2010 average of 109 egg masses.

Minnow traps set in Columbia Spotted Frog habitats at Mona Springs during 6-13 June captured numerous bullfrog tadpoles, ranging in length from 46 to 107 mm. Bullfrog tadpoles captured and euthanized on 11 August ranged in length from 97 to 142 mm. Numbers and measurements of all individuals were not recorded, but it appeared that most, if not all, of these tadpoles had hatched during the summer of 2010. Several Crayfish and hundreds of non-native fish were also captured and euthanized at Mona Springs during June and August of 2011.

Sevier River GMU

San Pitch River Subunit

Columbia Spotted Frogs in the San Pitch River Subunit, in Sanpete County, inhabit ponds and marshes along the San Pitch River corridor over a linear distance of approximately 12 km in the vicinity of Fairview. These habitats are now discontinuous, with highways, agricultural fields, and housing developments forming migration barriers between them. It is likely that connectivity between breeding habitats was much more extensive in the past, facilitating migration of Columbia Spotted Frogs between localized populations (demes) and fostering a metapopulation structure. Eight separate breeding sites were monitored in 2011. Monitoring surveys took place on 28 March, 11 April, and 20 April. Columbia Spotted Frog egg masses were detected at four of the eight monitoring sites.

The number of egg masses at these four sites ranged from low to moderate (n = 1, 7, 9, and 13).

Numbers of Columbia Spotted Frog egg masses detected during annual monitoring in the Fairview area have been relatively low since annual monitoring began there in 1994. The 30 egg masses detected in 2011 was actually higher than average (Table 3). The limited number of active breeding sites and the low reproductive output is of concern, but there is no evidence of a prolonged decline in reproductive output since 1994 (Figure 6).

West Desert GMU

Ibapah Valley Subunit

Columbia Spotted Frog monitoring surveys were conducted at Ibapah Valley in 2011 on 24 March, 31 March, and 14 April. Ibapah Valley is occupied by a single widely distributed metapopulation of Columbia Spotted Frogs, but separate monitoring data has traditionally been reported for the northern and southern portions of the valley due to between-site differences in monitoring history, habitats, and land ownership. Surveys at the currently designated North Ibapah monitoring sites began in 2006. Surveys at the currently designated monitoring sites at South Ibapah have been conducted every year since 1997, except during 2008. The number of egg masses detected at North Ibapah in 2011 was 470, which was more than three times higher than the 2010 total of 126 (the previous high). The number of egg masses observed at South Ibapah monitoring sites during 2011 was 683, which was more than three times higher than the 2010 total of 181 egg masses, and markedly higher than the previous high of 358 from 1997 (Figure 7). A significant positive correlation exists between the numbers of egg masses detected at North Ibapah and South Ibapah during the years in which data from the monitoring sites in both portions of the valley were collected (r = 0.996, n = 5, $P < 0.001$). This correlation, in combination with the unusually high numbers of egg masses detected in 2011, indicates that the metapopulation of Columbia Spotted Frogs at Ibapah Valley experienced an increase in the number of breeding adults in 2011 that was substantially larger than any increase evident during the previous 15 years of monitoring.

Snake Valley Subunit

The UDWR Central Region encompasses two of the five wetlands of the Snake Valley that are known to support Columbia Spotted Frog populations: the Leland Harris Spring Complex and a large wetland 2.5 km to the north, referred to as Miller Springs, which is seasonally connected to the Leland Harris Spring Complex. Columbia Spotted Frog surveys conducted in 2011 at the Leland Harris Spring Complex took place on 12 March, 30 March, and 13 April. Miller Springs was surveyed on 13 March, 30 March, and 12 April. The number of egg masses detected at the Leland Harris Spring Complex was 1740, which is much higher than is typical for the population (Table 3), exceeding the previous high of 936 egg masses in 1996 by more than 800 egg masses. Past monitoring data indicate that the breeding population of Columbia Spotted Frogs at Miller Springs was consistently larger during 1998-2002 than in the years before or after this period. However, 980 egg masses were detected during monitoring surveys in 2011 at Miller Springs, which is more than in any year since 2002. The combined total of 2720 egg

masses for Miller Springs and Leland Harris in 2011 was the highest on record (Figure 8).

Despite their close proximity to one another, the Columbia Spotted Frog populations at the Leland Harris Spring Complex and Miller Springs have exhibited somewhat dissimilar trends over the years, and there is no evidence of a significant positive relationship between numbers of egg masses detected at the Leland Harris Spring Complex and numbers detected at Miller Springs between 1995 and 2011 ($r = 0.278$, $n = 16$, $P = 0.280$). Under the assumption that trends in abundances of breeding adults in the two populations are essentially independent, and using the 1995-2011 data as the reference for expected values, the joint probability of observing egg mass numbers as high or higher than the 2011 totals for Leland Harris and Miller Springs was $(1/17) \times (6/17) = 0.0208$. This indicates that 2011 was an unusual year in terms the high numbers of reproductively active Columbia Spotted Frogs in the portion of the Snake Valley encompassed by the UDWR Central Region. This trend closely parallels the trend at Ibapah Valley, and suggests that reproductive output was high for Columbia Spotted Frog populations throughout the West Desert GMU in 2011.

Comparisons of the five Columbia Spotted Frog breeding sites where habitat variables were measured in the southwest portion of the Leland Harris Spring Complex in 2011 to sites in which habitat surveys were conducted in 2010 revealed that some, but not all, of the distinguishing features of the 2010 breeding sites were shared with the 2011 breeding sites. The 16 Columbia Spotted Frog breeding sites for which habitat data were obtained in 2010 were each sites in which egg masses were observed again in 2011. The eight sites at which no Columbia Spotted Frog egg masses or tadpoles were observed in 2010 also lacked breeding activity in 2011. Both sets of breeding sites were of larger surface area, had less steeply sloping shoreline habitat, and had lower solute concentrations than the sites in which there was no evidence of breeding activity. The original 2010 analyses had indicated that breeding sites also had higher length-width ratios, more submerged vegetation, and more emergent vegetation than other sites. These features were not consistently evident at the 2011 sites in the southwestern (SITLA) portion of the spring complex (Table 5). Unlike the northeastern breeding habitats investigated in 2010, the southwestern breeding habitats that were quantified in 2011 had length-to-width ratios and percentages of submerged vegetative cover that were similar to those of the eight sites that were not used by Columbia Spotted Frogs for breeding purposes. The average percent coverage of emergent vegetation at the 2011 breeding sites was very similar to the average for the 2010 breeding sites (46.6% and 48.1%, respectively), but the high variation and small sample size in the 2011 data resulted in the lack of a significant difference between the 2011 breeding sites and the eight sites in which no breeding occurred. As in 2010, the solute concentrations (conductivity) of the water at the five breeding habitats from which measurements were obtained in 2011 tended to be several times lower solute than solute concentrations measured at the sites at which there was no evidence of breeding activity (Table 5).

Russian Olives were uprooted or cut and treated with herbicide over approximately 29 hectares (72 acres) of the Leland Harris Spring Complex on 12-13 October and 15-16 December of 2011.

Cut and uprooted Russian Olive trees were piled in upland habitat along the edge of the spring complex in preparation for burning. Russian Olives were relatively sparse over much of this area, but had formed dense stands of mature trees in places, particularly along the edges of the northeastern portion of the spring complex (Figure 9). The entire northeast portion of the spring complex was cleared of Russian Olives during 2011 (Figure 10). Any newly germinated seedlings or small trees that were overlooked will be removed during Columbia Spotted Frog monitoring in 2012. In addition, the southwest portion of the spring complex will be cleared of Russian Olives in the fall of 2012.

DISCUSSION

The long-term monitoring data from surveys of Columbia Spotted Frog populations in the UDWR Central and Northern regions indicate that 2011 was a year characterized by unusually high reproductive output for the majority of the populations. Nine of the 12 populations for which long-term monitoring data were available produced relatively high numbers of egg masses in 2011, and four of them produced more egg masses than during any previous year of monitoring (Table 4). These four populations (Leland Harris, Ibapah Valley, Heber Valley, and Diamond Fork) occur in four different subunits of the Central Region in habitats ranging from desert spring complexes and marshes in the West Desert GMU to riparian wetlands and beaver ponds in the mountains of the Wasatch Front GMU. This suggests that a widespread environmental factor or combination of factors influenced the abundance and/or breeding activity of adult Columbia Spotted Frogs over much of Utah in 2011. The most conspicuous environmental factor that deviated from normal over much of Utah in 2011 was spring (March-May) precipitation. The spring of 2011 was the wettest 90-day period on record for northern and central Utah. The West Desert and Wasatch Front GMUs were particularly wet, with spring precipitation totals reaching 300-400% of normal in western Juab County, southwest Tooele County, and portions of the Wasatch Front (Utah Climate Center 2011).

Prior to 2011, the most recent period in which multiple populations of Columbia Spotted Frogs across much of the Utah exhibited relatively high levels of egg mass production was 1997-2001. Populations of Columbia Spotted Frogs at Holladay Springs, Springville, Mona Springs, Burraston Marsh, and Ibapah Valley began a period of relatively high reproductive output in 1997 and continued to produce relatively high numbers of egg masses until 2001 (Figures 4,5, 7, and 8). Miller Springs exhibited an identical trend over roughly the same time period from 1998 to 2002. This period of high reproductive output began during the usually warm and wet conditions associated with the 1997-1998 El Niño event. The fact that both 2011 and the previous period of relatively high egg mass production by Columbia Spotted Frogs coincided with wet periods suggests that reproductive output is positively correlated with precipitation. A positive relationship between egg mass numbers and rainfall totals prior to the period of egg deposition has been documented for populations of other ranid species (Jensen et al. *2003; Hartel 2008).*

However, a formal analysis of relationships between precipitation and reproductive trends of Columbia Spotted Frogs in Utah has not yet been conducted.

The 2011 Columbia Spotted Frog monitoring data from the UDWR Central and Northern regions suggests that the majority of the populations are doing well in comparison to past years. However, tallies of egg masses are best viewed as indicators of annual reproductive output that can reflect the number of adult females in the population, the probability of an adult female breeding during a particular year, or both. Columbia Spotted Frogs from populations inhabiting mild, low-elevation climates grow faster and reach sexual maturation earlier than Columbia Spotted Frogs from high-elevation habitats; and females from low-elevation habitats tend to reproduce annually, whereas those from colder high elevation habitats reproduce once every 2-3 years (Licht 1975; Reaser 2000). Consequently, between-population comparisons of egg mass numbers should consider site-specific environmental factors that are likely to influence demographic trends and breeding frequency. Temporal variation in environmental factors should also be considered when interpreting trends in egg mass production. For example, McCaffrey and Maxell (2010) documented that both survival and the probability of breeding declined with increasing winter severity during 2001-2008 for Columbia Spotted Frogs in the Bitterroot Mountains of Montana. This indicates that a portion of the variation in egg mass numbers is attributable to the variation in number of breeding adults, but that additional variation results from spatial and temporal factors that influence the probability that an individual female will reproduce during a given year. In addition, the tendency for amphibian populations to exhibit highly variable year-to-year trends in egg mass production often complicates the assessment and detection of long-term population trends (Scherer and Tracey 2011). Despite these limitations, the long-term data on egg mass numbers from surveys of Columbia Spotted Frog populations in the UDWR Central and Northern regions provides evidence of a very successful reproductive year for the majority of the populations in 2011, regardless of the strength of the relationship between egg mass numbers and the sizes of breeding populations. This burst of high egg mass production is likely to have a positive impact at the population level in light of the fact that many amphibian populations depend on brief, but infrequent, episodes of high reproductive output for long-term viability (Pechman and Wilbur 1994; Meyer et al. 1998).

Wasatch Front GMU

Provo River Subunit

The population of Columbia Spotted Frogs in the Heber Valley has exhibited an encouraging trend of relatively high egg mass production during recent years. The Heber Valley population was negatively impacted in the past by the loss and alteration of riparian and wetland habitats along the Provo River, which began in the 1940s with channelization of the river to accommodate increased discharge rates resulting from the input of water diverted from the Duchesne and Weber rivers as part of the Provo River Project (undertaken by the US Bureau of Reclamation), and continued until the completion of Jordanelle Reservoir in 1993. The impacts from these water projects necessitated extensive restoration work to return the river and associated wetland habitats to semi-natural conditions (Olsen 2009). The Utah Reclamation, Mitigation and

Conservation Commission began work on the Provo River Restoration Project (PRRP) in 1999 to restore habitats in the Heber Valley portion of the river corridor. Emphases of the project included returning the river to its natural channel and creating numerous riparian marshes and ponds to provide habitat for Columbia Spotted Frogs and other wetland species. Monitoring data going back to 1996 indicates that the breeding population of Columbia Spotted Frogs in the Heber Valley increased steadily from 2002 to 2005, with numbers of egg masses recorded during annual monitoring more than doubling during that period. Reproductive output has been consistently high since 2005, with the 2011 total of 1091 egg masses representing the highest number yet detected during annual monitoring of the Heber Valley population (Figure 3). This trend indicates that the Provo River Restoration Project has been highly successful in restoring breeding habitats of Columbia Spotted Frogs in the Heber Valley. Additional habitat enhancement could potentially be achieved through water management practices that emphasize improving habitat stability during the breeding season, which would likely result in increased survival of eggs and larvae and lead to further expansion of the population (Grover et al. 2012).

The metapopulation of Columbia Spotted Frogs distributed along the Upper Provo River, upstream from Jordanelle Reservoir, has exhibited an unusually consistent level of reproductive output since annual monitoring surveys began at the current monitoring sites in 2003. A possible explanation for the consistent level of reproductive output exhibited by Columbia Spotted Frogs along the Upper Provo River is that breeding habitats are relatively stable there. The majority of the breeding habitats are off-channel beaver ponds in which favorable hydrologic conditions are maintained by beaver activity, which maintains relatively consistent water levels at the ponds used as Columbia Spotted Frog breeding sites and dampens the influence of fluctuating precipitation and discharge rates. Numbers of egg masses detected during annual monitoring surveys have ranged from 417 to 622, despite climatic fluctuations. The 2011 total was at the low end of this range, but unusually heavy and late snowfall in the high elevation habitats of the upper Provo River delayed the onset of the breeding season by roughly a month and may have limited opportunities for reproduction. Elevations of Columbia Spotted Frog habitats range from approximately 1900 to 2200 m along the upper Provo River, which is near the upper elevational range of Columbia Spotted Frog habitats in Utah. Females in high elevation habitats are less likely to breed during a given year than are females from warmer low-elevation habitats, and the proportion of adult females that breed declines with increasing snowpack and winter severity (Reaser 2000; McCaffrey and Maxell 2010). Consequently, it is likely that a significant proportion of the adult females in the upper Provo River population did not breed during the spring of 2011.

The recently discovered population of Columbia Spotted Frogs at Boulder Creek, a tributary to the North Fork of the Provo River, occurs in habitats reaching elevations as high as 2500 m. This population was monitored at multiple breeding sites for the first time in 2011. Egg masses were present at all three sites that were surveyed in 2011, with a total of 22 egg masses detected. Mortality of adults, juveniles, and embryos was recorded during May and June at Boulder Creek, most likely as a result of late season snowfall and cold weather. Reproductive activity was probably more restricted by

environmental factors for this population in 2011 than for any other population in the UDWR Central and Northern regions. However, the data obtained in 2011 indicates that a widely distributed and viable population of Columbia Spotted Frogs is present at Boulder Creek. The discovery of this population at Boulder Creek and adjacent habitat along the North Fork of the Provo River emphasizes that additional, undiscovered populations likely occur in the Upper Provo River Drainage. Until Columbia Spotted Frogs were discovered in 2010-2011 in this area, previous surveys in the Provo River Subunit had largely focused on habitats associated with the mainstem Provo River.

The repatriation site in the Provo River Subunit, at Shady Dell, was surveyed for Columbia Spotted Frogs and egg masses on 1 June, 7 June, and 21 June of 2011. No Columbia Spotted Frogs or egg masses were observed. The Shady Dell site was established during the spring of 2007 and has been surveyed every year since that time. The most recent stocking of Columbia Spotted Frog tadpoles at Shady Dell occurred on 20 May 2009. Female Columbia Spotted Frogs typically require 3-6 years to reach sexual maturity (males mature 1-2 years earlier), with females from cool high elevation sites growing slower, maturing at smaller sizes, and taking longer to mature than females from lower elevation sites (Turner 1960; Licht 1975; Reaser 2000). Consequently, any surviving females from the 2009 cohort would have been too young to reproduce at the time of the 2011 surveys, and it is possible that females from the 2007 and/or 2008 cohorts were present, but had not yet reached sexual maturity. Habitats at Shady Dell have changed in the past three years. Many of the beaver dams within the Shady Dell complex appear to have been notched, resulting in lower water levels and an overall reduction in habitat suitable for Columbia Spotted Frogs. Beavers have not rebuilt these dams, potentially because of trapping activity, which was observed at Shady Dell during 2010 and 2011. The reduction of suitable Columbia Spotted Frog habitat at Shady Dell may be related to the absence of breeding at this location.

The Columbia Spotted Frog population at Wallsburg was monitored for the fourth time in 2011. The number of egg masses detected during these surveys has been consistently low (2-6 egg masses per year), but surveys have been restricted to a single pond and the population likely breeds in additional habitats on private land that are not currently accessible for monitoring. Additional exploratory surveys of ponds and riparian wetlands in the Wallsburg area will be necessary to evaluate the extent and viability of this population.

Upper and Lower Weber River Subunits

The Taylor's Fork repatriation site, which was stocked with Columbia Spotted Frog tadpoles from 2008 to 2010, was monitored for the first time in 2011. The 11 egg masses detected during these surveys indicate that the effort to re-introduce Columbia Spotted Frogs to Taylor's Fork has met with initial success. Females from the 2008 cohort of tadpoles were likely the only ones old enough to have reached sexual maturity by 2011, which suggests that reproductive output is likely to increase in the near future as females from the 2009 and 2010 cohorts begin to breed. The presence of egg deposition sites downstream from the original location where Columbia Spotted Frog tadpoles were

released suggests that this population is expanding and will continue to expand into suitable habitats.

The repatriated population at Swaner Preserve produced egg masses in 2008 and 2009, but there was no evidence of Columbia Spotted Frog breeding activity in 2010 or 2011. The one pond in which egg masses were detected in 2009 had very little emergent shoreline vegetation and high densities of Sandhill Cranes (*Grus canadensis*) – large omnivorous birds that nest in wetlands and prey opportunistically on frogs (Tacha et al. 1992). A total of seven breeding pairs of Sandhill Cranes were observed during the 2 May 2011 survey at Swaner Preserve, and a Sandhill Crane nest was located just a few meters from the egg deposition site used by Columbia Spotted Frogs in 2009. Smaller ponds at the repatriation site have abundant shoreline cover and serve as breeding sites for Boreal Chorus Frogs (*Pseudacris maculata*), but may lack suitable egg deposition sites for Columbia Spotted Frogs. A thorough and quantitative evaluation of habitat features at Swaner Preserve is needed to address the question of whether current habitat conditions are likely to meet the requirements of Columbia Spotted Frogs for successful reproduction.

Spanish Fork River Subunit

Two of the three Columbia Spotted Frog populations in the Spanish Fork River Subunit showed signs of expanded breeding activity in 2011. The breeding population at Diamond Fork produced more egg masses than in any previous year of monitoring and moved into a habitat restoration area for the first time. Adults were found as far away as the Spanish Fork River later in the year, suggesting that the Diamond Fork population is currently expanding in distribution. The number of egg masses produced by the Springville population in 2011 ($n = 81$) was four times higher than in any other year during the past decade, indicating that this population is recovering from a decline that began in 2001. By contrast, the Holladay Springs population appears to be experiencing a prolonged decline. The three egg masses detected at Holladay Springs in 2011 was a small fraction (< 2%) of the number of egg masses found during 1998-2000 surveys, but was typical of the reproductive output documented since 2003.

The Diamond Fork population has been the focus of extensive habitat restoration and mitigation work that has enhanced and expanded breeding habitats in the area. Breeding habitats of the Springville population occur on UDWR land, and have been largely protected from degradation, although they have become increasingly isolated from other wetland habitats due to urban and suburban development. By contrast, the Holladay Springs population is found exclusively on parcels of private land used for agricultural purposes (horse or cattle grazing) where there have been no opportunities for enhancement or protection of Columbia Spotted Frog habitats. The extremely limited reproductive output of the Holladay Springs population from 2003 through 2011 suggests that it may no longer be viable.

Utah Lake Subunit

The Mona Spring and Burraston Marsh populations of Columbia Spotted Frogs appear to have recovered from a decline that became most severe in 2003 and 2004, and have

exhibited relatively high levels of reproductive output since 2007 (Figure 5). However, breeding habitats have been degraded by agricultural activities in portions of the Burraston Marsh, and reproduction may now be restricted to one area in the northwest portion of the marsh (referred to in past reports as the Burraston Powerlines site). The Mona Springs population is found primarily within the Mona Springs WMA, but faces threats from non-native plants and animals, including Russian Olives, American Bullfrogs, Western Mosquitofish, and Red Swamp Crayfish. The most recent efforts to reduce populations of non-native species at Mona Springs have focused on removal of adult and larval bullfrogs as a means of preventing the expansion of the bullfrog population, but these efforts will need to be conducted on an ongoing basis because total elimination of the bullfrog population is unlikely and source populations of bullfrogs occur on adjacent land.

Western Mosquitofish, which are known to prey on amphibian larvae (Goodsell and Kats 1999), are widespread and abundant at Mona Springs, where they have greatly outnumbered all native fishes since 2007 despite extensive removal efforts (Grover and Crockett 2012). Finding an effective means of reducing Western Mosquitofish abundance at Mona Springs remains a major management issue. Management actions geared toward reducing negative impacts caused by Crayfish and Russian Olives at Mona Springs are also needed. Significant declines in the distribution and abundance of native amphibian species have been associated with the introduction of the Crayfish (Cruz et al. 2006). Crayfish have been euthanized when captured during bullfrog removal and Least Chub sampling at Mona Springs, but targeted removal of Crayfish may be necessary in the future. Removal of Russian Olives where former Columbia Spotted Frog breeding sites are now beneath the canopy of dense stands of mature trees could increase the availability of breeding sites and provide breeding opportunities in shallow spring pools where bullfrogs are not present. Clearing of Russian Olives at selected sites will begin in March of 2012.

Sevier River GMU

San Pitch River Subunit

The number of Columbia Spotted Frog egg masses detected during annual monitoring in the Fairview area in 2011 ($n = 30$) was consistent with numbers typically observed during the past decade (Figure 6). The limited reproductive output, loss of breeding habitats, and increasing level of isolation of local breeding populations of Columbia Spotted Frogs in the Fairview area dictates that effective habitat management and restoration activities will be necessary to ensure the long-term viability of the metapopulation of Columbia Spotted Frogs in the San Pitch River Subunit.

Most of the habitats occupied by Columbia Spotted Frogs in the San Pitch River Subunit are on private land subject to livestock grazing. Livestock grazing has been linked to reductions in the survival of amphibian egg masses and larvae, declines in amphibian abundance, and significant reductions in amphibian species diversity (Healey et al. 1997; Knutson et al. 2004; Schmutzer et al. 2008). Impacts of cattle and other livestock on amphibians are not always negative and may depend on grazing intensity and the species of amphibians present in the area. However, ranids (members of the family of frogs to

which Columbia Spotted Frogs belong) can experience reduced reproductive success in response to livestock grazing even under grazing regimes that are neutral or beneficial to other types of amphibians (Burton et al. 2009). Conservation easements that include restricted livestock grazing in wetland habitats will continue to be a necessary component of any successful strategy for conservation of Columbia Spotted Frogs in the San Pitch River Subunit.

West Desert GMU

Ibapah Valley Subunit

Columbia Spotted Frogs appear to be increasing in numbers in the Ibapah Valley. Far more egg masses were observed during monitoring in 2011 than during any previous year of monitoring. Breeding habitats of Columbia Spotted Frogs at Ibapah Valley are found on several parcels of private land, BLM land, and land belonging to the Confederated Tribes of the Goshute Indian Reservation. These habitats have not been colonized by non-native fishes or amphibians and have not been extensively fragmented. Impacts from livestock grazing and other agricultural activities appeared to be relatively light at most breeding sites in 2011, but have been problematic in the past (Crockett et al. 2009). Continued efforts to establish conservation easements and formulate grazing management plans with local landowners will be important in maintaining the integrity and interconnectivity of breeding habitats necessary to ensure the long- term viability of the metapopulation of Columbia Spotted Frogs in Ibapah Valley. Mitochondrial DNA (mtDNA) sequence data indicates that Columbia Spotted Frogs in the Ibapah Valley belong to a distinct clade (genetically distinguishable population) that does not appear to share any mtDNA haplotypes with other clades in Utah or elsewhere (Bos and Sites 2001, Funk et al. 2008). The unique phylogenetic position of the Ibapah population makes its preservation a particularly high management priority.

Snake Valley Subunit

The two Columbia Spotted Frog populations in the portion of the Snake Valley within the UDWR Central Region both exhibited high levels of reproductive output in 2011. More egg masses (n = 1740) were detected at the Leland Harris Spring Complex in 2011 than in any previous year of monitoring, and the 980 egg masses observed at Miller Springs was the highest number tallied there since 2002. The Miller Springs population and a large portion of the Leland Harris population are on private land that is seasonally grazed by cattle, but both populations have benefited from land management practices that include a rotational grazing regime in which grazing impacts are minimized and few, if any, cattle are present during the spring breeding season. Grazing impacts on the SITLA land in the southwest portion of the Leland Harris Spring Complex have also been minimal. Both the Leland Harris and Miller Springs populations have benefitted from their remoteness relative to urban and major recreational areas. The remoteness of these populations is probably the primary reason that they, like the Ibapah population, have not been impacted by introductions of non-native fishes or amphibians. By contrast, all Columbia Spotted Frog populations in the Wasatch Front and Sevier River GMUs occur in wetlands or in association with rivers or streams in which at least one species of non-native fish known to prey on amphibians has been introduced.

The wetland plant communities at the Leland Harris Spring Complex and Miller Springs are comprised primarily of native species, but Russian Olives are common in portions of the Snake Valley and have increased in abundance along the periphery of the Leland Harris Spring Complex during recent years. The Russian Olive removal project that began at the Leland Harris Spring Complex in 2011 will be expanded to include Miller Springs in 2012 and will ultimately involve removal of dense stands of Russian Olives on Bureau of Land Management (BLM) property between Miller Springs and the Leland Harris Spring Complex. We anticipate that the project will reverse the gradual displacement of native species of wetland plants by Russian Olives and will provide Columbia Spotted Frogs with greater access to favorable thermal environments necessary for incubation of egg masses and successful development of larvae. Monitoring surveys will be conducted to investigate whether egg deposition occurs in these areas after Russian Olives have been removed.

RECOMMENDATIONS

Wasatch Front GMU

Repatriation of Columbia Spotted Frogs to former breeding habitats in the Wasatch Mountains has been an emphasis of management activities in the UDWR Central and Northern regions. We now have experience and information from three attempts at repatriating populations: one of which resulted in limited but temporary reproductive success, one of which yielded higher than expected numbers of egg masses during 2011 (the first year in which reproduction was anticipated), and another of which has yet to produce any evidence of reproduction or juvenile recruitment. Follow-up monitoring that incorporates a comparative evaluation of habitat features and biotic factors at the three repatriation sites will be needed to understand the factors that may have contributed to the success or failure of each of these repatriation efforts. The information gleaned from analyses of repatriation strategies and characteristics of repatriations sites can then be used, in combination with information obtained from repatriation efforts involving similar species (e.g., Oregon Spotted Frogs), to develop guidelines to improve the success of future repatriation work.

The vast majority of the Columbia Spotted Frog surveys conducted by UDWR biologists during recent years have been monitoring surveys conducted to document the distribution and reproductive output of known populations. The discovery during 2010-2011 of Columbia Spotted Frog breeding sites in the Upper Provo River drainage at three locations, ranging from high elevation beaver ponds along the upper portion of Boulder Creek to the confluence of Boulder Creek and the North Fork of the Provo River, confirms that surveys of additional tributaries of the Upper Provo River are needed to determine the distribution of Columbia Spotted Frogs in the Provo River Subunit. More undiscovered populations may exist.

Management emphases for Columbia Spotted Frog populations in the Wasatch Front GMU during 2012 will include habitat restoration and evaluation of completed habitat restoration projects. Russian olives associated with shallow spring pools in the northeast

portion of the Mona Spring WMA will be removed in early March of 2012. Thick mats of watercress (*Nasturtium officinale*), along with accumulated sediments, will also be removed from portions of these spring pools to create open shallow shoreline habitats suitable for egg deposition. Follow-up monitoring will begin in late March. Continued monitoring of the habitat restoration area at Diamond Fork will also occur during the spring of 2012.

Populations of Columbia Spotted Frogs in the Utah Lake, Spanish Fork River, and Provo River subunits of the Wasatch Front GMU have tested positive for *Batrachochytruim dendbrobatidis* (*Bd*), the fungal pathogen responsible for amphibian chytridiomycosis (Crockett et al. 2009). Amphibian chytridiomycosis has been implicated in the declines and extinctions of multiple amphibian species, but responses of amphibians to *Bd* infection vary greatly between species, between populations of the same species, and even between entire amphibian communities in different types of ecosystems (Blaustein et al. 2005; Hossack et al; 2010; Vredenburg et al. 2010). Interspecific variation in susceptibility to *Bd*-induced mortality appears to be largely attributable to differences in antimicrobial skin peptides (Rollins-Smith and Conlon 2005; Woodhams et al. 2007). Recent research indicates that Oregon Spotted Frogs (*Rana pretiosa*) are resistant to *Bd*-induced mortality and have natural defenses that eliminate *Bd* infections (Padgett-Flohr and Hayes 2011). The persistence and stability of Columbia Spotted Frog populations that have tested positive for *Bd* infection in Utah and elsewhere suggests that they, like Oregon Spotted Frogs, possess natural defenses against *Bd*. However, defensive responses to *Bd* infection entail an energetic cost that can reduce individual growth rates, which implies that the influence of *Bd* on resistant amphibians is not entirely benign (Padgett-Flohr and Hayes 2011). A controlled experiment designed to investigate the susceptibility of Columbia Spotted Frogs to *Bd* infection and *Bd*-induced mortality is needed in order to evaluate the potential threat of *Bd* to Columbia Spotted Frog populations in the Wasatch Front GMU and elsewhere. An experimental investigation of this issue would be an ideal thesis project for a graduate student at one of the universities within the boundaries of the UDWR Central or Northern region.

Sevier River GMU

Management activities that include pursuing and finalizing conservation easements, obtaining water rights necessary to restore one or more breeding ponds, and exploring opportunities for additional restoration projects along the San Pitch River will continue in 2012. Plans for future restoration work will emphasize creating suitable breeding habitat adjacent to existing habitat as a means of increasing the total amount of available breeding habitat while increasing the connectivity between breeding habitats used by isolated to semi-isolated local populations of Columbia Spotted Frogs in the San Pitch River Subunit.

West Desert GMU

Protecting the relatively pristine habitats of Columbia Spotted Frogs in the West Desert GMU will always be a challenge. Of the 1740 egg masses detected at the Leland Harris Spring Complex in 2011, 717 were on SITLA property to in the southwest portion of the spring complex. The acquisition of this property, through either a direct purchase or land

swap, would be a major accomplishment for the UDWR in its efforts to effectively manage habitats of sensitive species in the Snake Valley. A proactive effort to eradicate Russian Olives (*Elaeagnus angustifolia*) from Columbia Spotted Frog habitats in the Snake Valley began in 2011 and will be expanded to include Miller Springs and the southwest portion of the Leland Harris Spring Complex in 2012.

Columbia Spotted Frogs in the Leland Harris Spring Complex and other spring-fed wetlands in the Snake Valley rely heavily on adequate spring discharge rates to provide thermally suitable overwintering habitats and to prevent the accumulation of solutes in spring pools used as egg deposition sites. Spring pools characterized by high solute concentrations are osmotically stressful to most amphibians, and are not used for breeding purposes by Columbia Spotted Frogs (Grover et al. 2012). Reduction in groundwater levels resulting from climate change, groundwater withdrawal, or both, is potentially the most significant threat to populations of Columbia Spotted Frogs and other sensitive species in the West Desert GMU. Habitat monitoring at the Leland Harris Spring Complex and Miller Springs will expand in scope in 2012 to supplement information obtained from analyses of habitat features conducted during 2010-2011. In addition, spatial and temporal patterns in data from Columbia Spotted Frog monitoring surveys will be analyzed in the context of recent groundwater monitoring data to explore possible relationships between variation in groundwater levels and variation in the distribution and reproductive output of Columbia Spotted Frogs at the Leland Harris Spring Complex and Miller Springs.

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TABLES

Table 1. Columbia Spotted Frog populations monitored during 2011 in the UDWR Central and Northern regions. The average date for the onset of breeding activity for each population during past (prior to 2011) surveys is shown. Populations are grouped according to Geographic Management Unit (GMU) and subunit, with the USGS hydrologic unit code (HUC) shown for each subunit. Land ownership of the habitats of each population is also shown. Federal lands include Bureau of Land Management (BLM) and Forest Service (USFS) parcels.

GMU	Subunit	HUC	Population	Land Ownership	Onset of Breeding
Wasatch Front	Provo River	16020203	Wallsburg	Private	3/25
			Heber Valley	State (PRRP)	3/24
			Upper Provo	Private/State/USFS	3/29
	Spanish Fork River	16020202	Diamond Fork	USFS	3/28
			Holladay Springs	Private	3/17
			Springville	State (UDWR)	3/22
	Utah Lake	16020201	Mona Springs	State (UDWR)/Private	3/24
			Burraston Marsh	Private	3/26
Sevier River	San Pitch River	16030004	Fairview	Private	3/28
West Desert	Ibapah Valley	16020306	Ibapah	Private	3/20
	Snake Valley	16020301	Leland Harris	Private/SITLA/BLM	3/13
			Miller Springs	Private	3/15

Table 2. Categories used by DWR biologists to classify Columbia Spotted Frog egg masses according to age or developmental stage.

Category	Size and Position in the Water Column	Appearance
Class 1	Small and round (roughly the size of a golf ball) and resting on the bottom substrate or submerged vegetation	Ova have dark spherical embryos and clear outer membranes
Class 2	Expanded and floating near the surface of the water.	Ova contain oblong embryos surrounded by opaque outer membranes
Class 3	Large (up to the size of a grapefruit) and floating at the surface, with the upper layer often above water	Upper layer of the egg mass often consisting of a desiccated white crust; embryos have tails
Class 3+	Large and beginning to disarticulate and spread out within the water column	Egg membranes beginning to break down and more than half of the embryos hatched.
Dead	Variable, often fragmented	Old egg masses in which most of the embryos are white and have failed to hatch

Table 3. The estimated date of the onset of breeding activity, date of peak breeding activity, and number of egg masses detected for each Columbia Spotted Frog population monitored in the UDWR Central and Northern Regions in 2011.

GMU	Subunit	Population	Breeding		Egg mass totals	
			Onset	Peak	Population	Subunit
Wasatch Front	Provo River	Wallsburg	3/31	3/31	2	1510
		Heber Valley	3/31	4/12	1091	
		Upper Provo	4/28	5/5	417*	
	Spanish Fork River	Diamond Fork	4/5	4/17	170	254
		Holladay Springs	4/7	4/7	3	
		Springville	3/24	4/7	81	
	Utah Lake	Mona Springs	3/27	4/7	55	120
		Burraston Marsh	3/27	4/11	65	
Sevier River	San Pitch River	Fairview	4/11	4/20	30	30
West Desert	Ibapah Valley	Ibapah	3/24	4/14	1153	1153
	Snake Valley	Leland Harris	3/12	3/30	1740	2720
		Miller Springs	3/12	3/30	980	

*An additional 22 egg masses were found between 25 May and 6 June at newly discovered sites at Boulder Creek and the upper North Fork of the Provo River, but were not included with the total from traditional monitoring sites.

Table 4. Numbers of Columbia Spotted Frog egg masses detected during monitoring surveys in the UDWR Central and Northern regions in 2011 compared to average and median numbers from all years in which monitoring has taken place at current monitoring sites. The 25-75% quartile range (middle 50%) of the values and the rank of the 2011 total (with years ranked from the lowest to highest number of egg masses detected) is also shown for each population. The total reported for the Upper Provo population excludes the breeding sites at the North Fork of the Provo River and Boulder Creek, which were not discovered until 2010 and 2011.

Population	2011 Egg Mass Total	Data from all Years of Monitoring				2011 Rank
		Average	Median	25-75% Range	Time Span	
Wallsburg	2	3.3	2.5	3, 6, 2, 2*	2008-2011	1.5 of 4
Heber Valley	1091	664	628	447-799	1996-2011	16 of 16
Upper Provo	417	509	514	448-556	2003-2011	1 of 9
Diamond Fork	120	87	94	51-112	2003-2011	9 of 9
Holladay Springs	3	41	15	2-65	1994-2011	6.5 of 18
Springville	81	26	14	9-46	1994-2011	17 of 18
Mona Springs	55	39	33	20-57	1995-2011	13 of 17
Burraston Marsh	65	37	39	22-51	1995-2011	15 of 17
Fairview	30	25	24	17-30	1994-2011	14 of 18
North Ibapah	470	140	67	57-212	2006-2011	6 of 6
South Ibapah	683	234	182	146-318	1997-2011[§]	14 of 14
Leland Harris	1740	605	567	413-657	1995-2011	17 of 17
Miller Springs	980	648	335	246-1166	1995-2011	12 of 17

*Only four years of data, so all values are shown rather than the quartile range.
[§]No monitoring was conducted at South Ibapah in 2008.

Table 5. Average and median values of habitat variables measured at five Columbia Spotted Frog breeding sites in the southwest portion of the Leland Harris Spring Complex (SITLA property) in 2011 compared to average and median values from measurements of 16 breeding sites and eight sites in which there was no evidence of breeding activity, which were surveyed in the northeast portion of the spring complex in 2010. The range of values for measurement of each variable within each group is given in parentheses below the average and median values. Water depth is for the deepest point in the body of water. Sediment depth is the average of 40 measurements of the depth of loose benthic sediments at four distances from the shoreline (0.5 m, 1 m, 2 m, and 3m); shoreline depth is the average of 10 measurements of water depth at 0.5 m from the water's edge; and shoreline steepness represents the average value of 10 measurements of the cumulate increase in water depth moving from 0.5 m to 3 m from shore. Units for conductivity measurements are microsiemens per centimeter (µs/cm). An asterisk denotes a variable for which a Kruskal-Wallis test found a significant between-group difference ($P \leq 0.01$) and Bonferroni corrected Mann-Whitney pairwise comparisons indicated that both the 2011 and 2010 breeding sites differed significantly from the sites in which no breeding activity was detected.

Habitat Variable	2011 Breeding Sites		2010 Breeding Sites		No Breeding Activity	
	Average	Median	Average	Median	Average	Median
Surface Area (m^2)*	27165	1213	5545	2732	478	369
	(210 – 107956)		(487 – 33300)		(30 – 1078)	
Length/Width ratio	2.47	2.37	4.3	3.5	1.7	1.2
	(1.26 – 4.07)		(2.5 – 11.7)		(1.2 – 6.1)	
Max Water Depth (cm)	139	140	77.9	50.5	45.5	50
	(33 – 250)		(38 – 230)		(29 – 62)	
Shoreline Depth (cm)	15.9	15.1	14.3	13.5	11	10.2
	(6.7 – 24.7)		(8.8 – 22.9)		(6.2 – 21.8)	
Sediment Depth (cm)	19.8	3.1	7.7	6	3.9	2.3
	(1.4 – 71.6)		(0.5 – 29.1)		(0.8 – 10.6)	
Shoreline steepness*	8.6	7.5	6.1	6.4	15.1	14.2
	(2.1 – 17.1)		(-1.1 – 12.4)		(7.2 – 25.5)	
% Emergent Veg.	46.6	70	48.1	41.5	19.9	18
	(5 – 70)		(5 – 90)		(8 – 35)	
% Submerged Veg.	3.2	0	39.9	40	13.9	0.5
	(0 – 15)		(2 – 85)		(0 – 70)	
pH	7.90	7.96	8.43	8.30	9.11	9.22
	(7.63 – 8.12)		(6.89 – 10.14)		(8.28 – 9.65)	
Conductivity*	1095	736	922	937	14412	6170
	(513 - 2170)		(547 – 1758)		(1785 – 41880)	

FIGURES

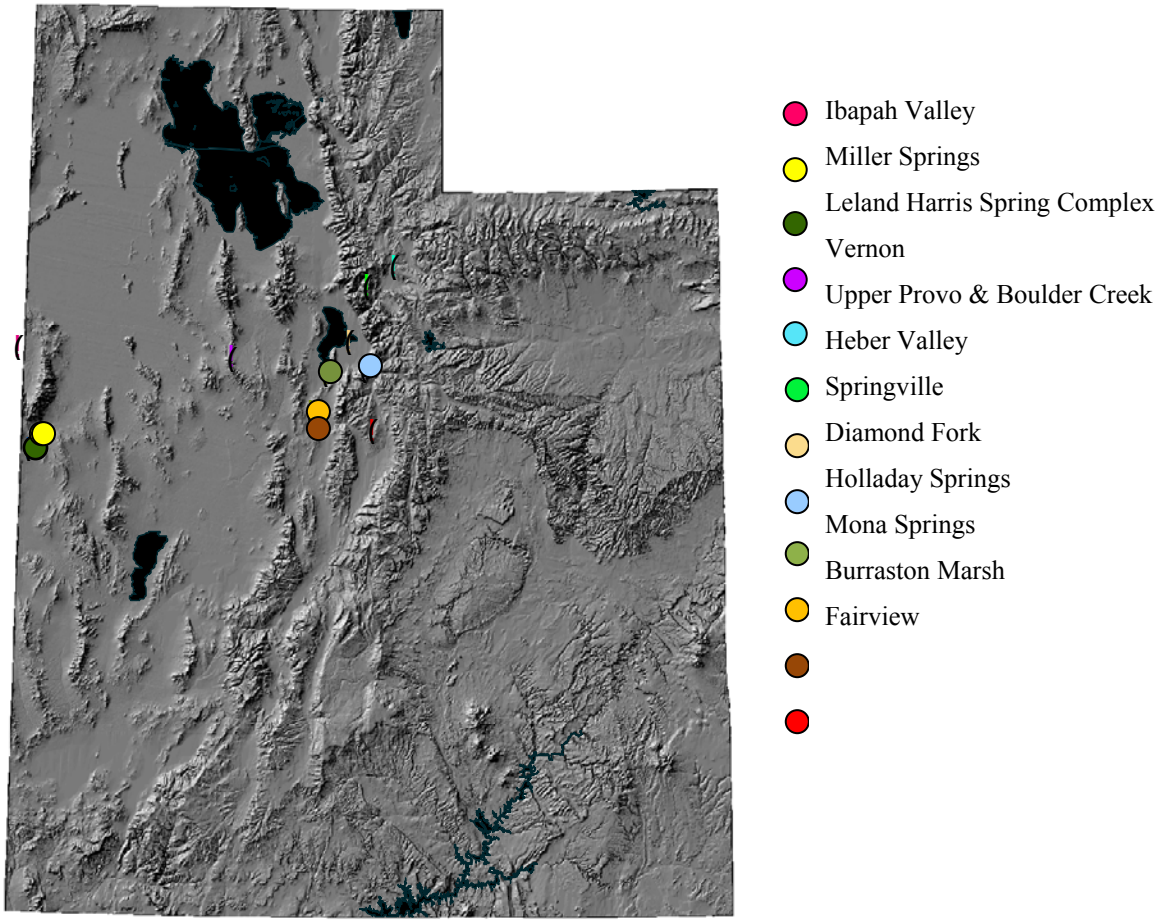

Figure 1. Locations of Columbia Spotted Frog populations in the UDWR Central and Northern regions. All populations except the Vernon population were monitored in 2011.

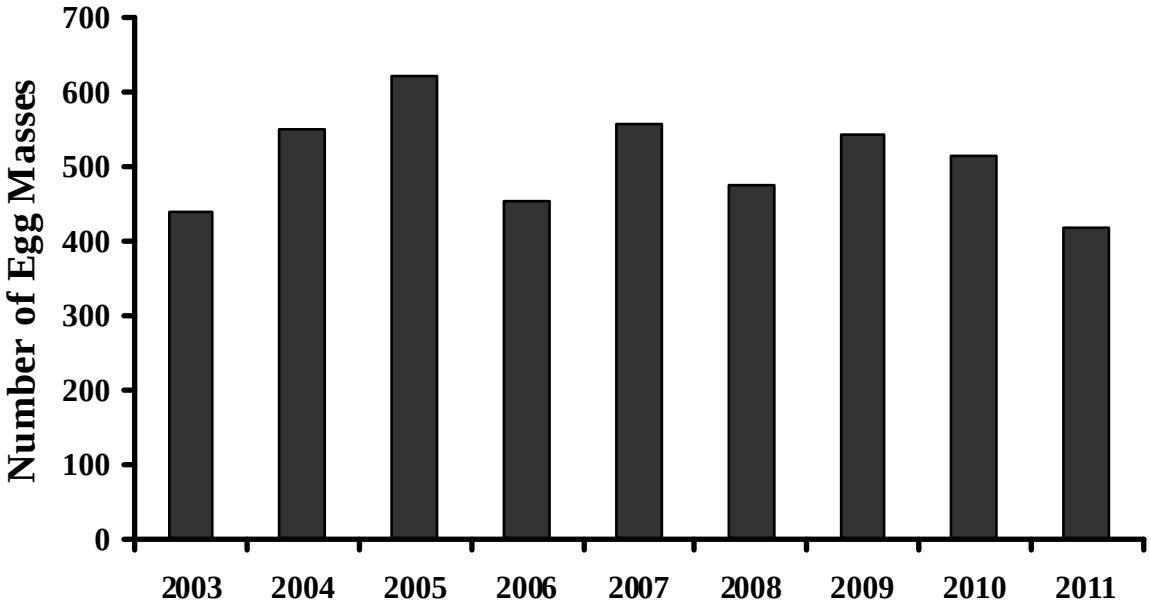

Figure 2. Numbers of Columbia Spotted Frog egg masses detected during annual monitoring from 2003 to 2011 at monitoring sites for the Upper Provo River population. Annual monitoring occurred prior to 2003, but took place at a subset of the current monitoring sites.

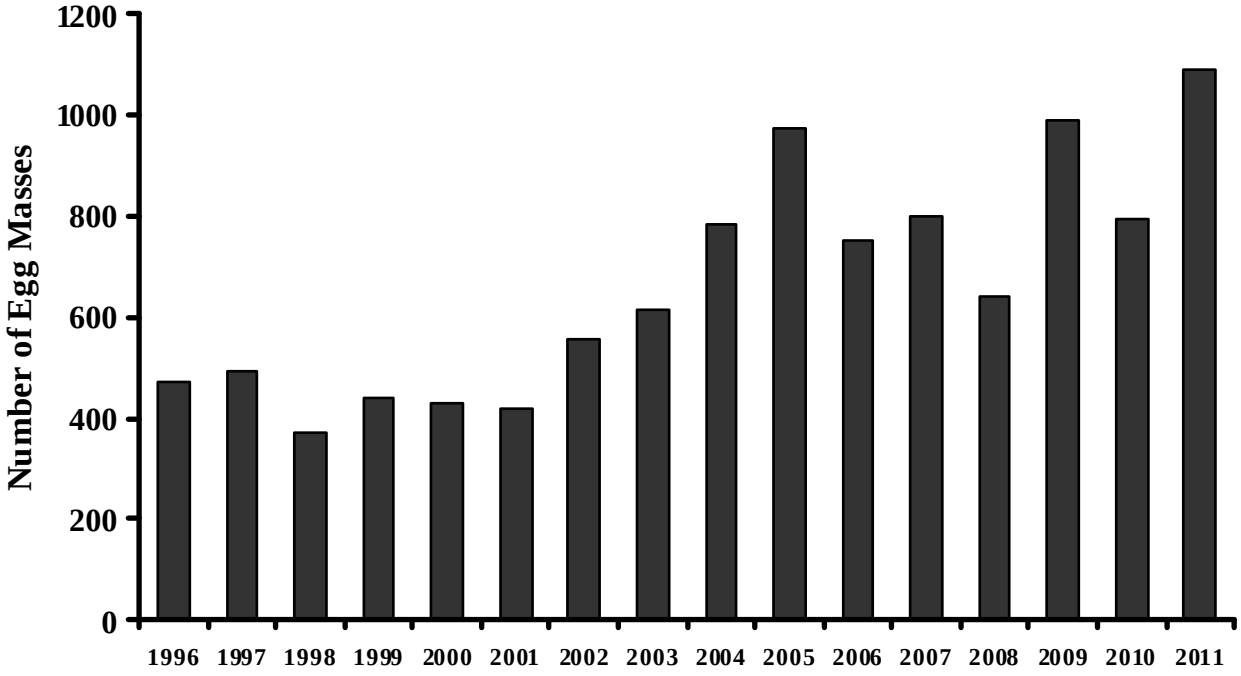

Figure 3. Numbers of egg masses detected during annual monitoring from 1996 to 2011 at Heber Valley monitoring sites.

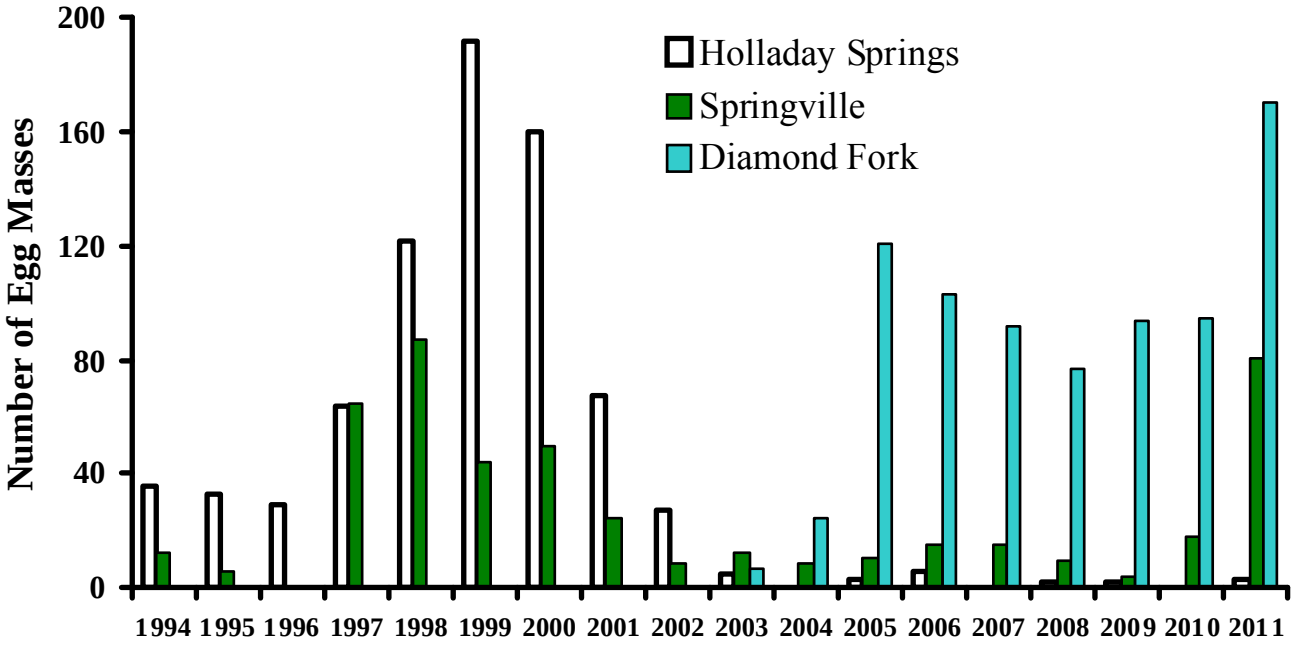

Figure 4. Numbers of Columbia Spotted Frog egg masses detected during annual monitoring of the three populations in the Spanish Fork Subunit from 1994 to 2011. The Diamond Fork population was not discovered until 2002 and has been monitored since 2003.

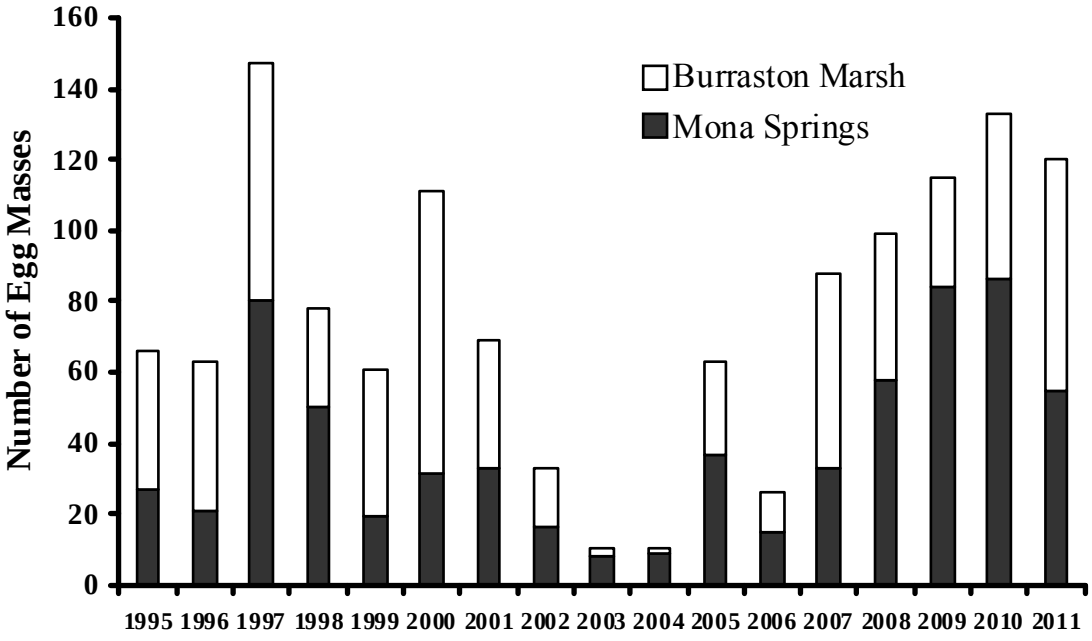

Figure 5. Numbers of Columbia Spotted Frog egg masses detected during annual monitoring of the Burraston Marsh and Mona Springs populations (Utah Lake Subunit) from 1995 to 2011.

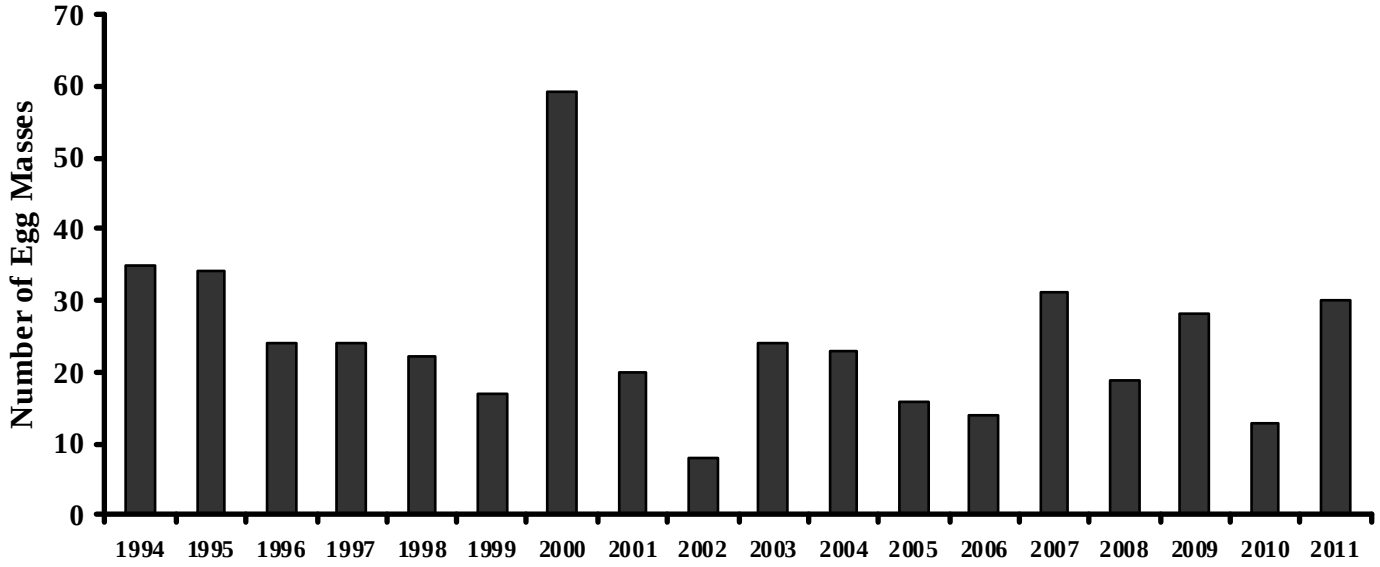

Figure 6. Numbers of Columbia Spotted Frog egg masses detected during annual monitoring at breeding sites in the Fairview area (Sanpete County) of the San Pitch River Subunit, Sevier River GMU, from 1994 to 2011.

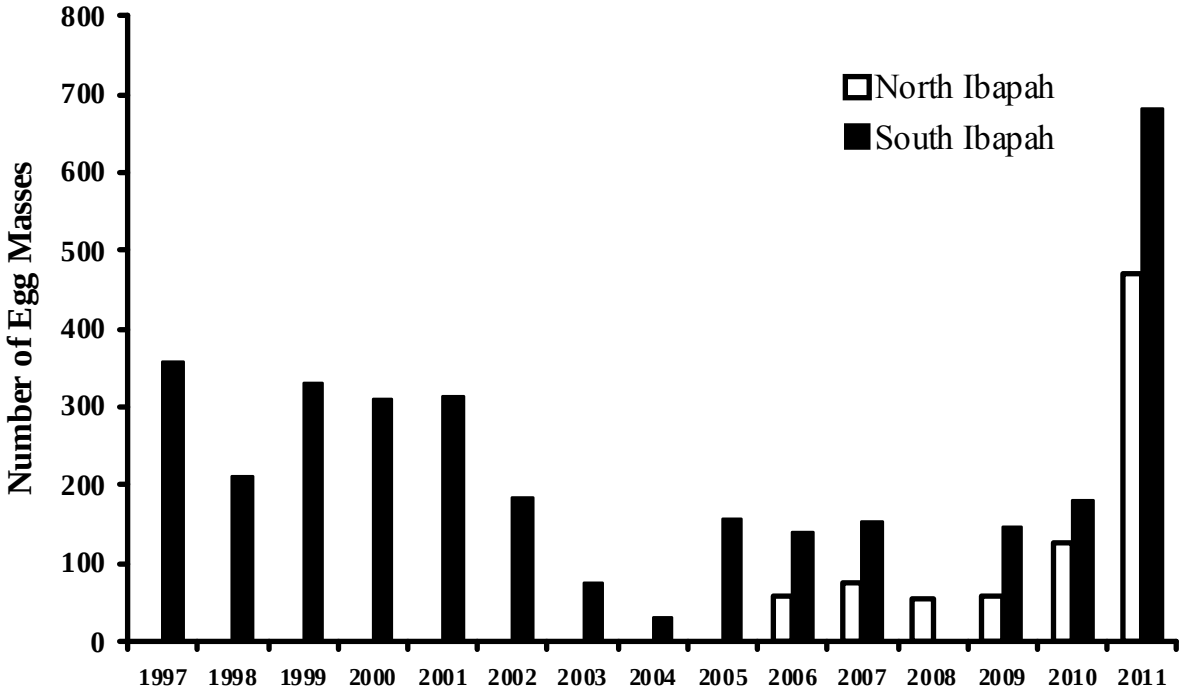

Figure 7. Numbers of Columbia Spotted Frog egg masses detected during annual monitoring in Ibapah Valley, Tooele County. The current North Ibapah survey area has been surveyed since 2006. Breeding sites at South Ibapah have been surveyed every year except 2008 since 1997.

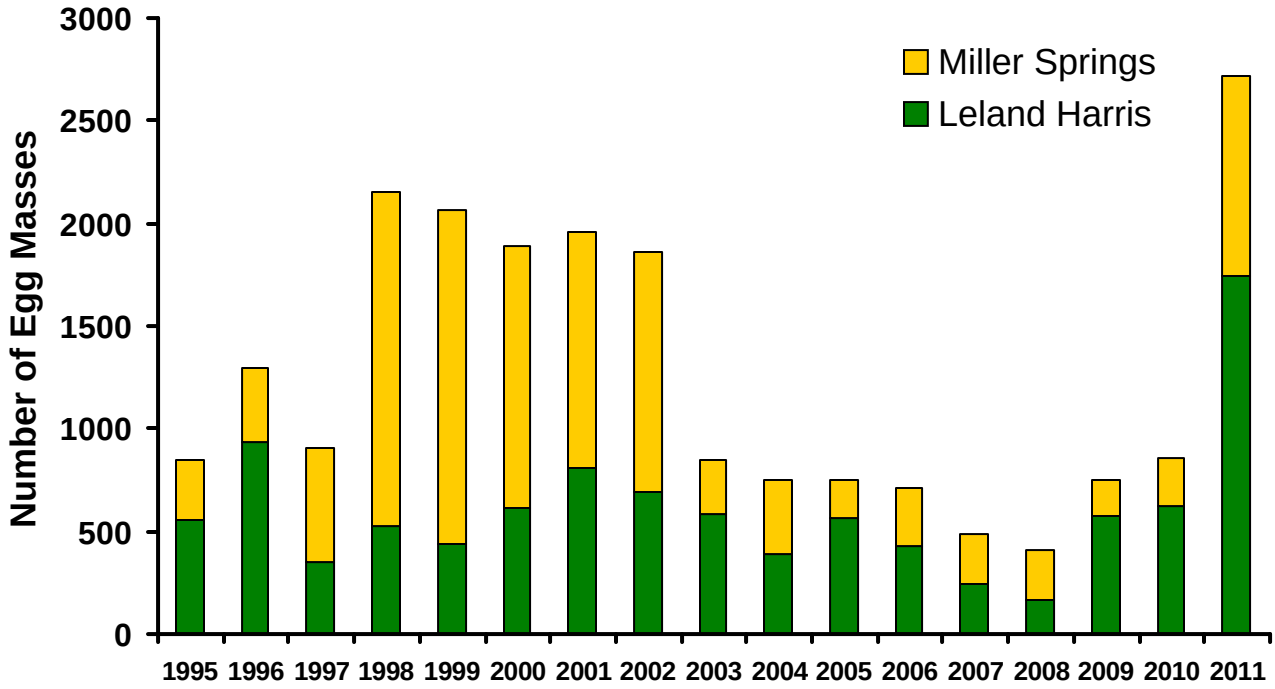

Figure 8. Numbers of egg masses detected during annual monitoring from 1995 to 2011 at the Leland Harris Spring Complex and Miller Springs wetland in the Snake Valley, Juab County.

Figure 9. A stand of Russian Olives along the edge of the Leland Harris Spring Complex on 11 October 2011, the day prior to the beginning of a habitat restoration project during which all Russian Olives in this region of the spring complex were removed.

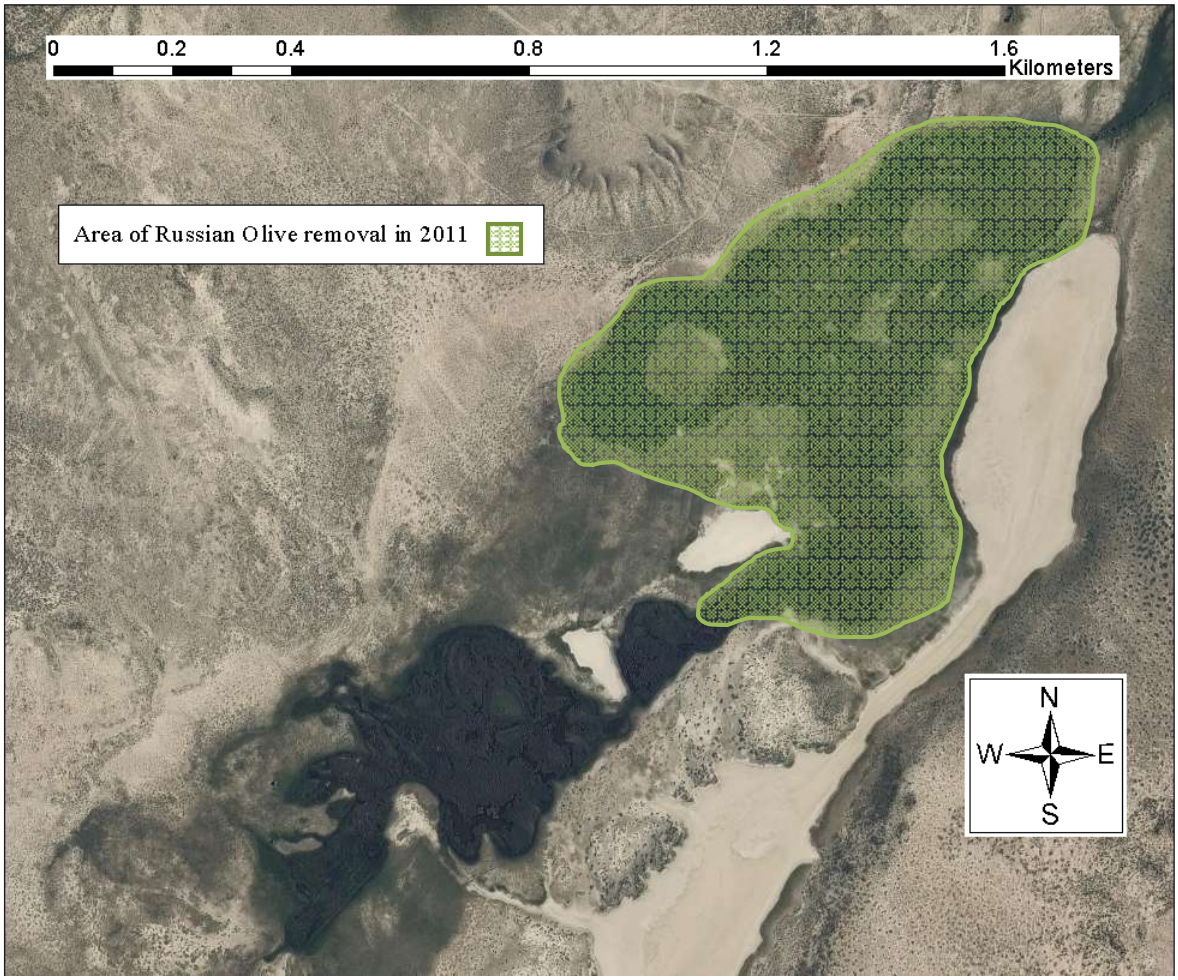

Figure 10. The portion of the Leland Harris Spring Complex from which Russian Olives were removed in 2011.

State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources - Native Aquatic Species

Columbia Spotted Frog Population Monitoring Summary & Conclusions: Tule & Southern Snake Valleys, 2011

II-Southern Region Report

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EXECUTIVE SUMMARY

In spring 2011, the Utah Division of Wildlife Resources conducted the 15th consecutive year of Columbia Spotted Frog (*Rana luteiventris*) monitoring in southern Snake Valley and Tule Valley, Utah. Visual encounter surveys were conducted at all population locations in the Southern Region for egg masses. In the Southern Region, egg mass numbers at most sites remained consistent with trends of previous years. Egg mass numbers in 2011 indicate stable populations, yet several threats remain to each population, and various projects are underway to eliminate or reduce these threats. Continued monitoring should show a population response to these management actions, or indicate areas of additional work necessary to provide for the long-term viability of Columbia Spotted Frog in Utah.

INTRODUCTION

Regional declines and threats to Columbia Spotted Frog (*Rana luteiventris*) populations led the Utah Division of Wildlife Resources (UDWR) to conduct inventories in 1993 and implement Columbia Spotted Frog conservation actions. The Columbia Spotted Frog Conservation Agreement and Strategy (CSFCAS; Perkins and Lentsch 1998; Bailey et al. 2006) was developed to coordinate these activities. A vital component of the CSFCAS is population monitoring in conjunction with habitat and population conservation and restoration activities. In an effort to monitor population trends, assess threats, and assess conservation measures, the UDWR Washington County Field Office has conducted annual population monitoring surveys since 1997 (Fridell et al. 2001). Because of the elusive nature of adult Columbia Spotted Frogs in Utah's West Desert and difficulty in obtaining accurate population estimates, egg mass counts have been used as a proxy for Columbia Spotted Frog relative abundance. Emerging threats, including proposed pumping from the aquifer supporting Columbia Spotted Frog habitat, emphasize the need for continued monitoring of these isolated populations. Various conservation activities, including non-native removal, habitat improvements, and water restoration, have been conducted in Snake and Tule Valleys to improve conditions for Columbia Spotted Frog.

The CSFCAS describes three Geographic Management Units (GMUs) for the Columbia Spotted Frog: Sevier River, Wasatch Front, and West Desert GMUs (Bailey et al. 2006). The designation of the GMUS is based on hydrologic subregions (United States Geological Survey 1974). Columbia Spotted Frog monitoring locations in the West Desert GMU include: Ibapah Valley, Snake Valley, Tule Valley, and Tooele Valley. This report summarizes monitoring efforts within Tule Valley and the southern portion of Snake Valley (Gandy Marsh, Bishop Springs, and Beck Springs). Columbia Spotted Frog populations in other subregions, as well as Miller Spring and Leland Harris Springs in northern Snake Valley, are monitored and reported by the Central Region of the UDWR.

METHODS

Study Area

Within southern Snake Valley, Gandy Marsh consists of numerous springheads and associated marshes along the western edge of the Gandy Salt Marsh Lake (Figure 1). Bishop Springs, the largest of the areas, contains four springs which feed into confined, fast-flowing streams spreading into numerous channels and large, shallow, open water marshes (Figure 2). Beck Springs consists of two small springs and associated outflow habitat (Figure 3).

Tule Valley contains 13 individual springs that comprise four geographically isolated marsh complexes. The northern-most marsh complex in Tule Valley is Coyote Spring (Figure 4). The Willow Springs complex consists of Tule 1, Tule 2, and Tule 8, (Figure 5) and the North Tule Springs complex contains Tule 3, Tule 4a, Tule 4b, Tule 4c, and Tule 5 (Figure 6). South Tule Springs (Tule 6: Figure 7) is the southern-most complex. Columbia Spotted Frog reproduction in Tule Valley is monitored within each of these individual springs.

Sampling Design

Monitoring surveys are conducted to document the majority of egg masses deposited at each population location. Area-constrained visual encounter surveys (VES) are used to locate new egg masses, track survival of previously encountered masses, and ensure that monitoring was conducted during the peak period of egg deposition. Site visits have been coordinated specifically to occur near onset of deposition (defined as the time when approximately ten percent of the average mass total has been deposited), and during peak egg deposition period. Although breeding is dependent on several variables, including weather, temperature, and hydrology, the onset of breeding in Snake and Tule Valleys has remained fairly consistent. Two to three visits are typically made during the peak of egg deposition, these visits being approximately one week apart.

Sampling protocol

VES were conducted at each site by walking transects along the banks and in shallow water searching for egg clusters, defined as egg masses located in close proximity (less than 0.3 m) to one another. All suitable habitat at each population location is searched. Egg mass age class, number of masses, and location (in UTM coordinates) are recorded on standardized data sheets for each site. Once documented, each cluster of masses is numbered and flagged to identify it in future surveys. Although all egg masses are recorded on subsequent visits to each location, new egg masses are noted separately to obtain a total count for the breeding season. All data is subsequently entered into Excel spreadsheets and reported in annual monitoring reports. Detailed methodology is provided in Fridell et al. (2001) and Wheeler and Fridell (2006).

To prevent the spread of disease, pathogens, or harmful biota between populations, boots and other equipment are disinfected between locations. All mud and debris is removed, and then equipment is sprayed or rinsed in a bath of 1:100 solution of Quat 128 (a quaternary ammonia compound). This is then rinsed off with water or dried completely before used in another location.

RESULTS

Columbia Spotted Frog monitoring at Tule and southern Snake Valleys was completed between 7 March and 12 April 2011. In 2011, sites were visited one to four times throughout the breeding period. The total number of egg masses detected within each area is presented in Table 1; Table 2 contains the number of egg masses observed at each site annually since 1997. Adult Columbia spotted frogs were observed at Gandy Marsh, Bishop Springs, Beck Springs, and Tule Valley. Adult and juvenile northern leopard frogs (*Lithobates pipiens*) were encountered in Snake Valley at Bishop Springs and Gandy Marsh. Age class breakdown of egg masses and observations for sites within Southern Snake Valley and Tule Valley are discussed separately below.

Snake Valley Subunit

At Gandy Marsh, 256 Columbia Spotted Frog egg masses were counted during spring 2011 monitoring (Table 1). Gandy Marsh was not visited until 31 March, when 246 egg masses were observed. Peak deposition had already occurred by this date. An additional 10 masses were found on 10 April (Figure 8). Numbers of egg masses observed at Gandy are larger than they have been since 2001 (Table 2, Figure 9). Since fall 2006, UDWR personnel have been manually restoring spring habitat within Gandy Marsh by removing dense aquatic vegetation and sediment from the springheads. This restoration has provided open water habitat for Columbia Spotted Frog, as well as Least Chub (*Iotichthys phlegethontis*) and other native species. Restoration work was conducted at 20 springs prior to spring 2011 Columbia Spotted Frog monitoring. In 2011, three sites that had previously been restored (springs 5, 8, and 57), but had since deteriorated, had additional vegetation and sediment removed. Restoration work at one spring (47) included digging the outflow channel to create a more efficient corridor. Also in 2011, over 200 individual purple loosestrife (*Lythrum salicaria*) plants were removed from the southern exclosure at Gandy Marsh.

The largest population of Columbia Spotted Frogs in Snake Valley remains at Bishop Springs with 745 egg masses observed during spring 2011 monitoring (Table 1). The onset of egg mass deposition had not yet occurred by 7 March when the location was first visited. Bishop Springs was re-visited on 25 and 30 March and 11 April (Figure 10). The number of Columbia Spotted Frog egg masses observed in 2011 is higher than any year previously monitored except 2007 (Table 2, Figure 11). Efforts to remove largemouth bass from Foote Spring continued; one bass was removed in 2011.

At Beck Springs, 305 Columbia Spotted Frog egg masses were observed during spring 2011 monitoring (Table 1). A total of 254 egg masses were observed in the north spring during the first visit on 7 March; several egg masses were in advanced stages, indicating that peak egg deposition had occurred. One additional visit was made on 31 March (Figure 12). The number of Columbia Spotted Frog egg masses observed during spring 2010 was higher than it has been since the population was discovered in 2005 (Table 2, Figure 13).

Tule Valley Subunit

At Coyote Spring, 1,442 egg masses were observed during spring 2011 monitoring. During the first visit on 8 March, 217 masses were observed, indicating that onset had probably occurred. Peak deposition had occurred by 24 March (Figure 14). Numbers of egg masses observed were high for Coyote Spring historic trends, with only two previous years (2003, 2009) exceeding the totals for 2011. (Figure 15). Egg masses at Coyote Spring comprised 44% of all egg masses observed in Tule Valley. UDWR has been removing tamarisk from Coyote Spring since 2008. In three visits during 2011, 5.8 additional hectares (bringing the total to 21.3 hectares) were cleared and sprayed with herbicide. Egg masses were found in previously cleared areas, indicating that Columbia Spotted Frogs are using the additional available habitat. With the exception of some ongoing maintenance, this completes the tamarisk removal at Coyote Spring.

A total of 556 egg masses were observed in the Willow Springs Complex, which consists of Tule 1 and Tule 2. Peak deposition had already occurred when the locations were first visited on 24 March. A total of 300 masses were observed at Tule 1 and 232 at Tule 2 on that date (Figure 16). Both sites were again visited on 29 March. The total egg mass count at this complex in 2011 was the highest number documented since monitoring began in 1997 (Figure 17). No egg masses were observed at Tule 8, which is also in this complex. Annually between 2008 and 2011, portions of egg masses from neighboring springs were translocated to restore the population at Tule 8. Sediment and vegetation were removed from portions of this wetland to improve breeding habitat. Frogs have not been observed following these introduction efforts.

A total of 1,147 egg masses were observed in the North Tule Springs Complex, which consists of Tule 3, Tule 4a, Tule 4b, Tule 4c, and Tule 5. Egg deposition was peaking at Tule 4a during the first visit on 8 March with 229 masses observed, indicating that onset had probably occurred a week before. The other locations in the complex had peaked by 25 March when they were first visited (Figure 18). The egg mass total for 2010 was lower than that for 2009 and 2010, but remained above average (Figure 19). Egg masses at North Tule Springs comprised 35% of all egg masses observed in Tule Valley.

At South Tule Springs, 156 egg masses were observed. Peak deposition had already occurred by 24 March. Onset likely occurred two weeks before (Figure 20). The total egg mass count for 2010 was higher than has been documented previously, but close to that of 2009 (Figure 21).

DISCUSSION

Columbia Spotted Frog egg mass counts in southern Snake Valley and Tule Valley indicate that populations remain stable. Several locations, including Bishop Springs, Beck Springs, Willow Springs Complex, North Tule Springs Complex, and South Tule Springs, all have higher than average egg mass numbers. Numbers of egg masses in Gandy Marsh are slightly higher than they have been in recent years, but remain lower

than pre-2002 levels. It is not understood what factors may have led to the decline of this population, but current habitat improvements, in the form of springhead restoration, may benefit the population. Additional spring restoration activities are being conducted. In 2011, vegetation and sediment were removed from one spring. Management of succession in spring complexes, particularly in exclosures may need to be evaluated to help recover the population.

Non-native plants, particularly Russian olive (*Elaeagnus angustifolia*) in Bishop Springs and purple loosestrife in Gandy Marsh, are potential threats to Columbia Spotted Frog habitat and efforts to control or remove these invasive plants should be a priority. In 2011, over 200 purple loosestrife plants were removed from the southern exclosure at Gandy Marsh. At South Beck Spring, additional frog breeding habitat may be created by increasing the depth of the outflow pool. Tamarisk (*Tamarix* sp.), an invasive, non-native tree, is present and recently expanding at Coyote Spring. Therefore, UDWR initiated removal efforts and has cleared 21.3 hectares (52.6 acres) between fall 2008 and summer 2011. The majority of the tamarisk has now been removed from this site and maintenance is planned. Egg masses were observed in 2011 in a bay that had been cleared of tamarisk in 2008, suggesting that tamarisk removal is improving conditions for Columbia Spotted Frog. Continued habitat restoration and population supplementation at Tule 8, where no eggs have been documented since 1997, is ongoing. A population of introduced southern platyfish (*Xiphophorus maculates*), a tropical aquarium fish, was discovered in Tule 4a in 2007. Adverse potential impacts of platyfish on Columbia Spotted Frog populations are currently unknown and should be evaluated.

RECOMMENDATIONS

Active recovery actions are necessary to manage and protect Columbia Spotted Frog populations in southern Snake Valley and Tule Valley from threats including invasive non-native species, habitat degradation due to grazing, and potential future groundwater withdrawal. Continued monitoring is necessary to evaluate potential impacts from these threats and the population level response to implementation of conservation projects.

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Table 1. Total number of Columbia Spotted Frog egg masses observed by age class (AC) in southern Snake Valley and Tule Valley, spring 2011.

Site	AC 1	AC 2	AC 3 & 3+	Dead	Total
Gandy Marsh	**36**	**146**	**73**	**1**	**256**
Bishop Springs	**436**	**191**	**117**	**1**	**745**
Beck Springs	**133**	**86**	**86**	**0**	**305**
Coyote Spring	**956**	**311**	**70**	**105**	**1,442**
Willow Springs Complex	**396**	**110**	**50**	**0**	**556**
North Tule Springs Complex	**605**	**375**	**141**	**26**	**1,147**
South Tule Springs	**2**	**6**	**147**	**1**	**156**

Table 2. Total number of Columbia Spotted Frog egg masses found in southern Snake and Tule Valleys, 1997 - 2011.

Year	Gandy Marsh	Bishop Springs	Beck Springs	Coyote Spring	Willow Springs Complex	North Tule Springs Complex	South Tule Springs
1997	406	Not surveyed	Not surveyed	957	129	290	35
1998	489	275	Not surveyed	Not Surveyed	Not Surveyed	441	Not Surveyed
1999	672	274	Not surveyed	651	111	385	72
2000	784	241	Not surveyed	950	108	573	0
2001	585	201	Not surveyed	1,124	151	868	34
2002	90	357	Not surveyed	1,282	217	685	19
2003	115	615	Not surveyed	2,585	185	1,079	21
2004	131	213	Not surveyed	1,039	108	179	3
2005	155	325	Not surveyed	1,375	186	590	1
2006	205	425	89	1,309	195	869	24
2007	114	891	82	1,072	270	767	22
2008	128	715	120	1,066	216	1,008	12
2009	121	704	156	1,850	324	1,748	150
2010	185	511	141	1,189	439	1,703	60
2011	256	745	305	1,442	556	1,147	156

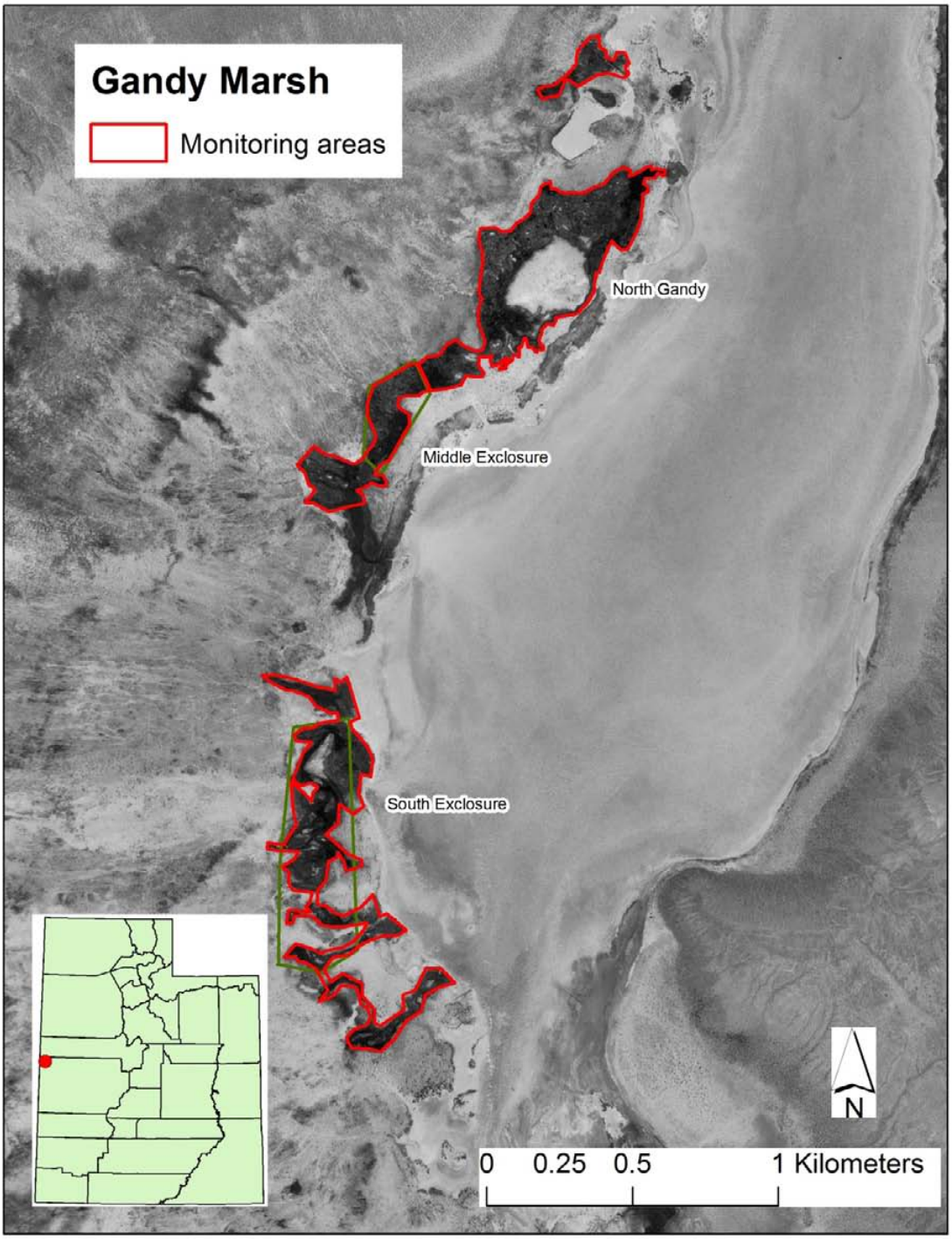

Figure 1. Location of Gandy Marsh Columbia spotted frog monitoring areas, Snake Valley, Utah (Gandy Quadrangle, 7.5 minute series).

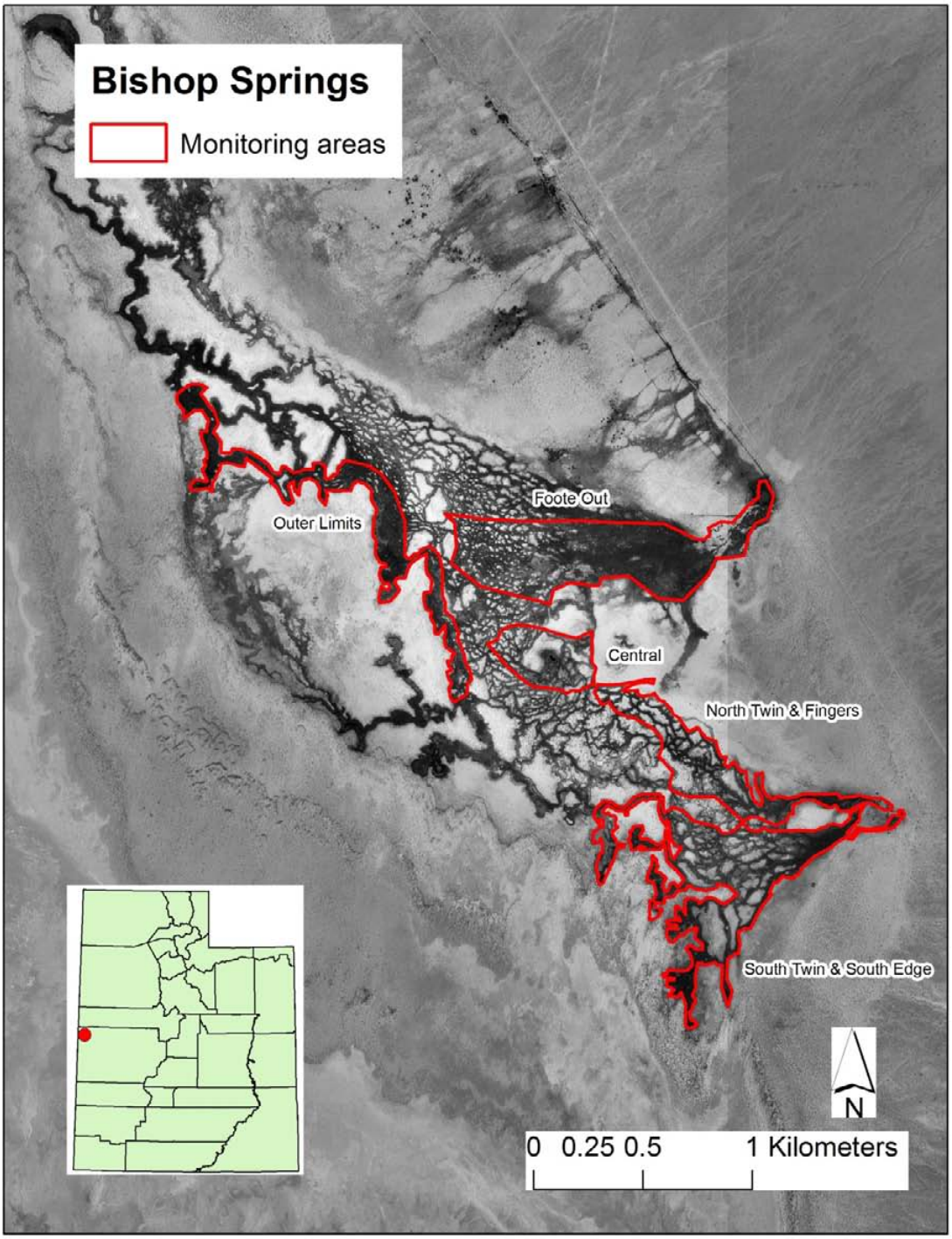

Figure 2. Location of Bishop Springs Columbia spotted frog monitoring areas, Snake Valley, Utah (Gandy and Foote Range Quadrangles, 7.5 minute series).

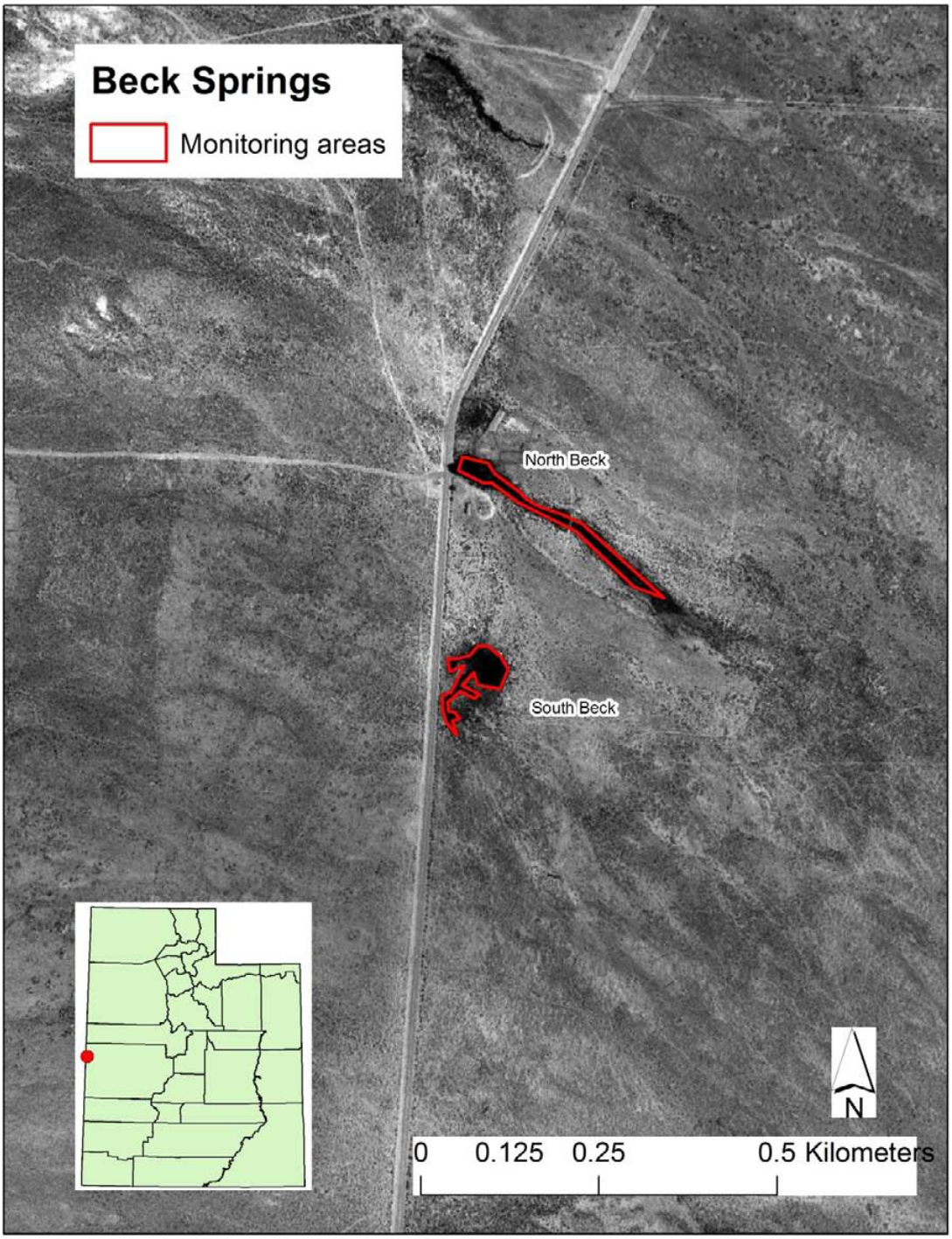

Figure 3. Location of Beck Springs Columbia spotted frog monitoring areas, Snake Valley, Utah (The Cove Quadrangle, 7.5 minute series).

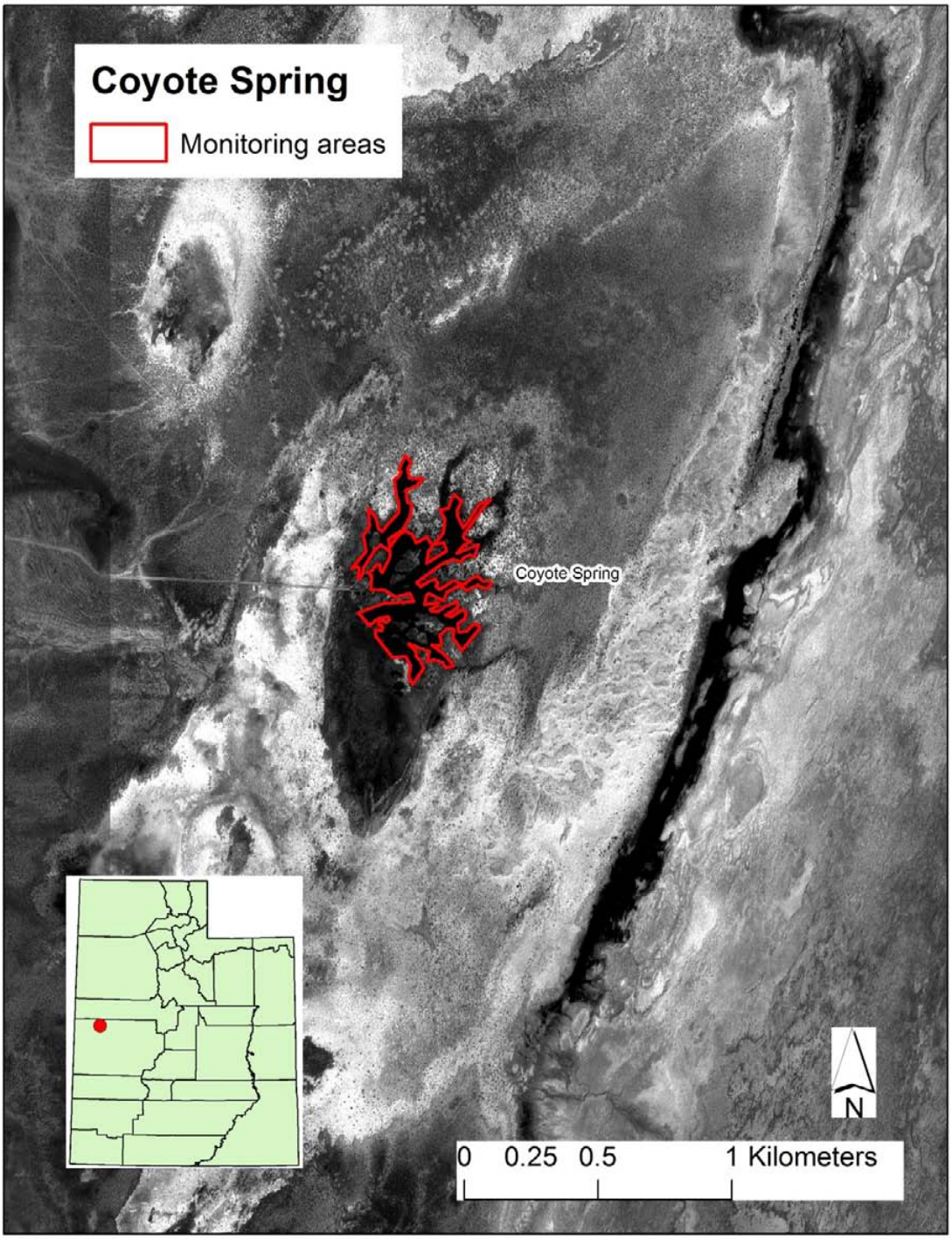

Figure 4. Location of Coyote Spring Columbia spotted frog monitoring areas, Tule Valley, Utah (Coyote Knolls Quadrangle, 7.5 minute series).

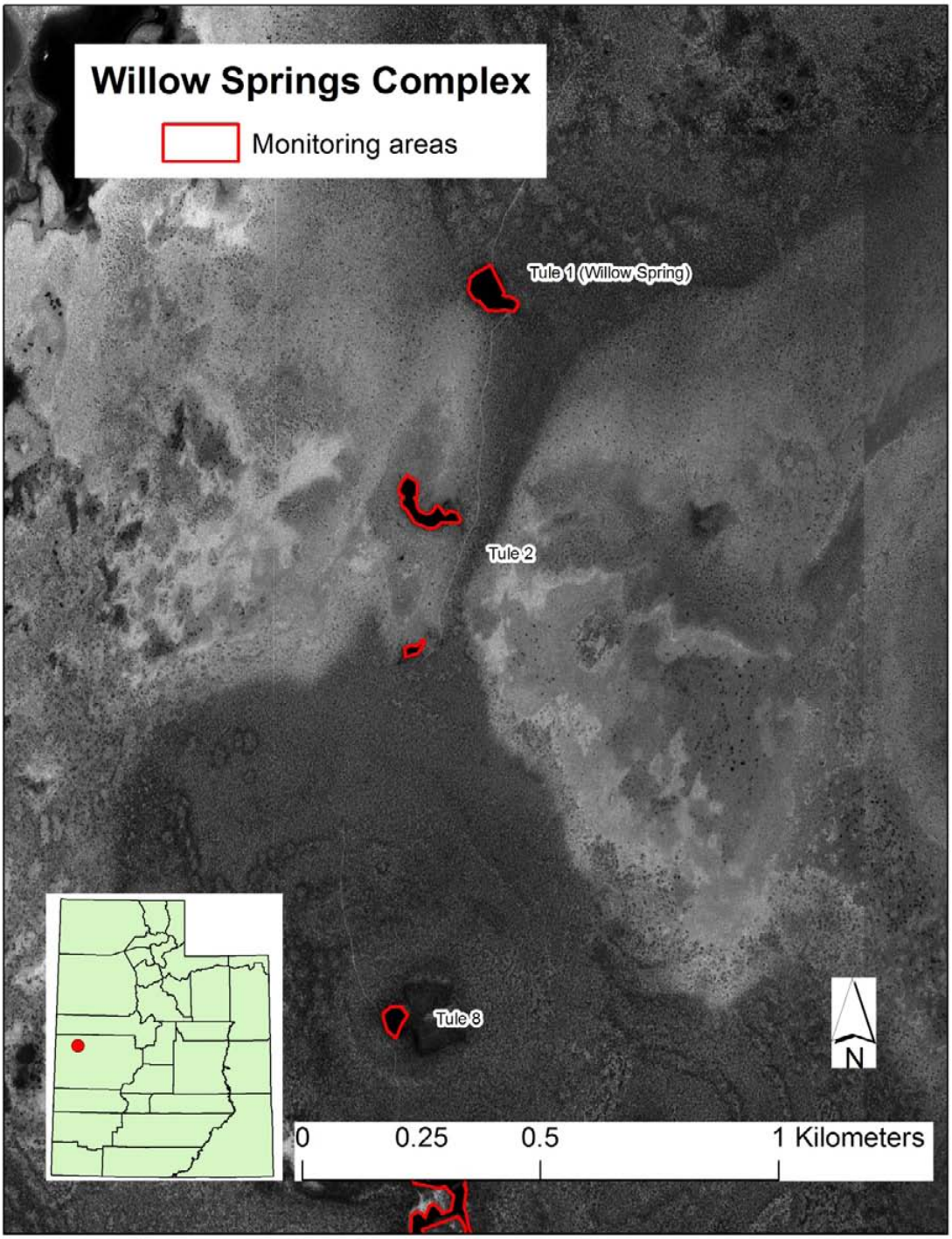

Figure 5. Location of Willow Springs complex Columbia spotted frog monitoring areas, Tule Valley, Utah (Chalk Knolls Quadrangle, 7.5 minute series).

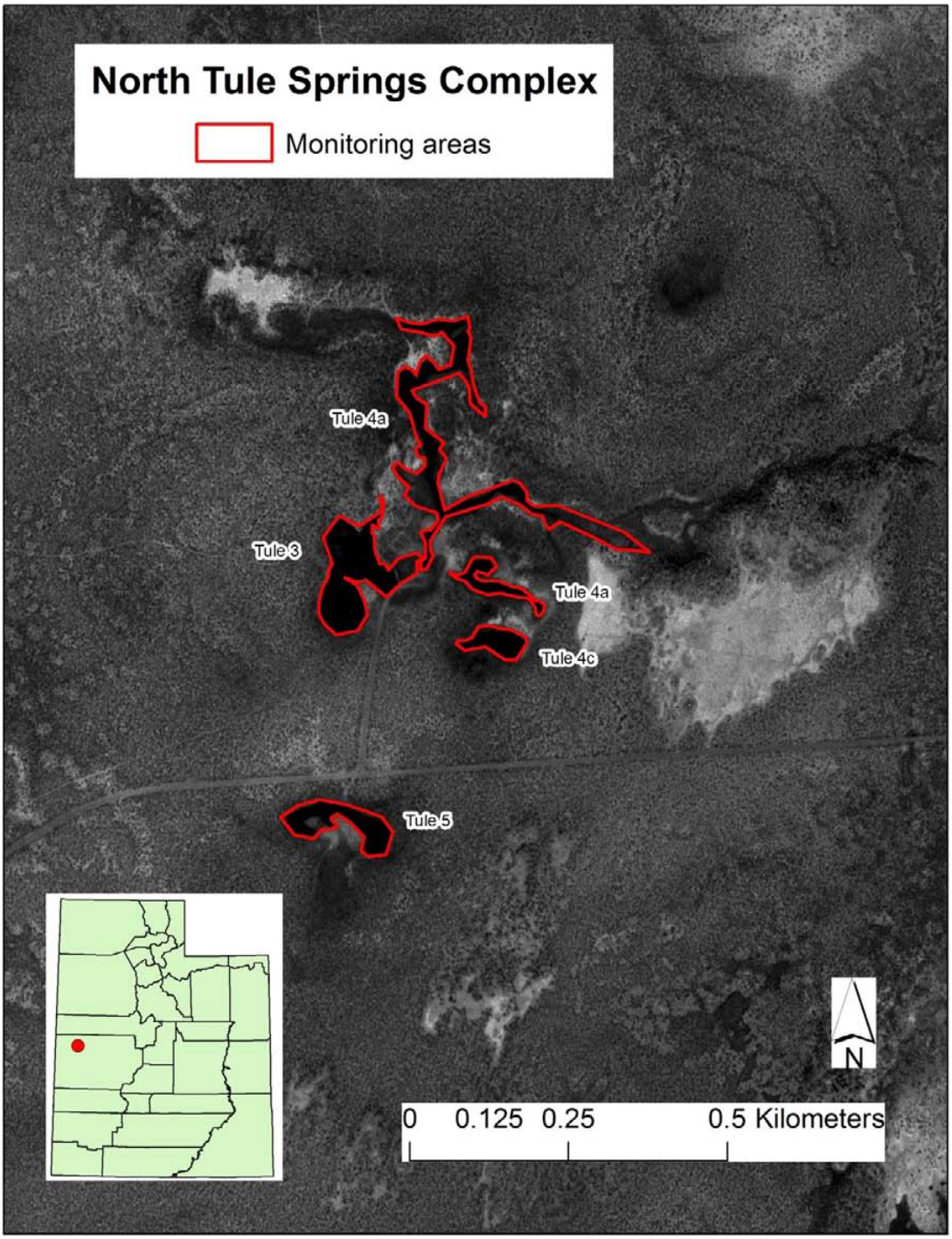

Figure 6. Location of North Tule Springs complex Columbia spotted frog monitoring areas, Tule Valley, Utah (Chalk Knolls Quadrangle, 7.5 minute series).

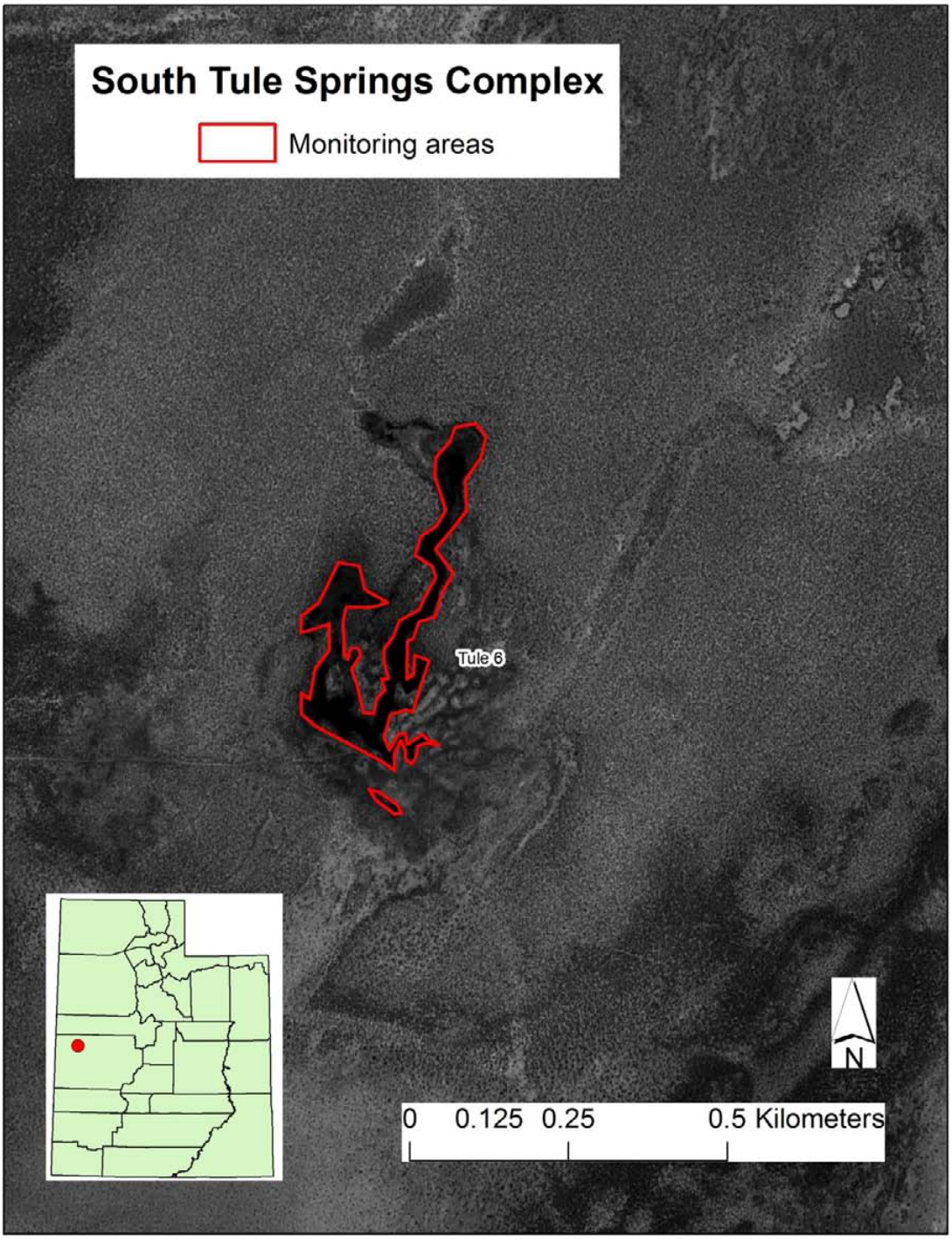

Figure 7. Location of South Tule Springs Columbia spotted frog monitoring areas, Tule Valley, Utah (Chalk Knolls Quadrangle, 7.5 minute series).

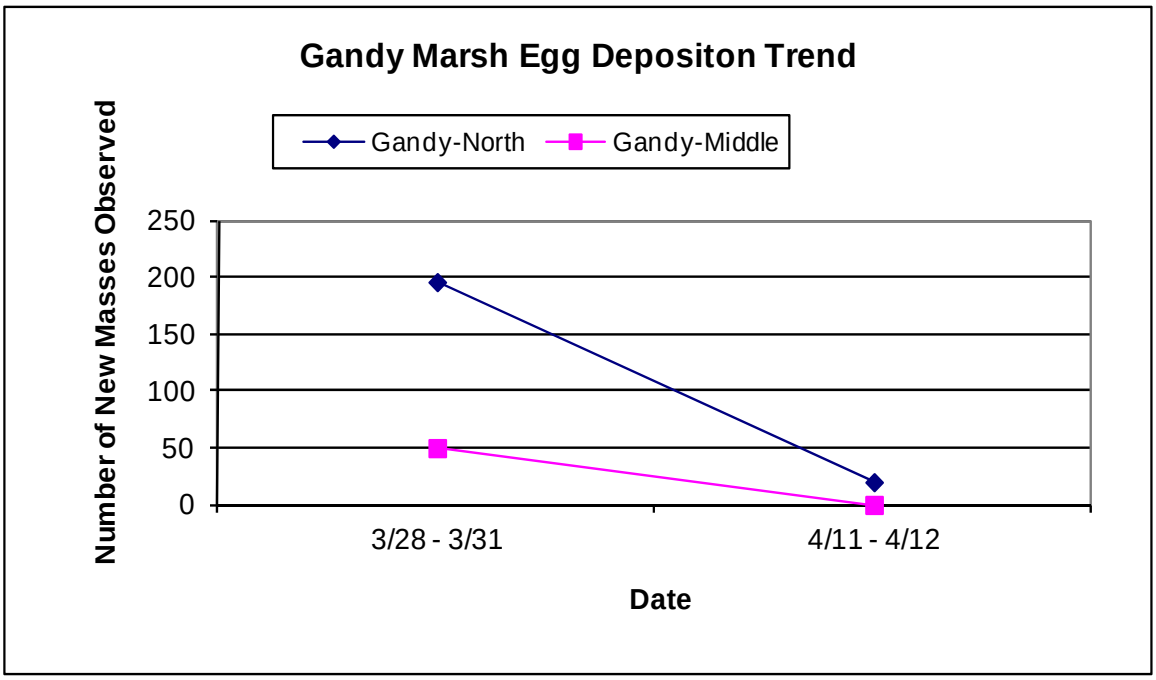

Figure 8. Columbia spotted frog egg mass deposition trend observed at Gandy Marsh during spring 2011.

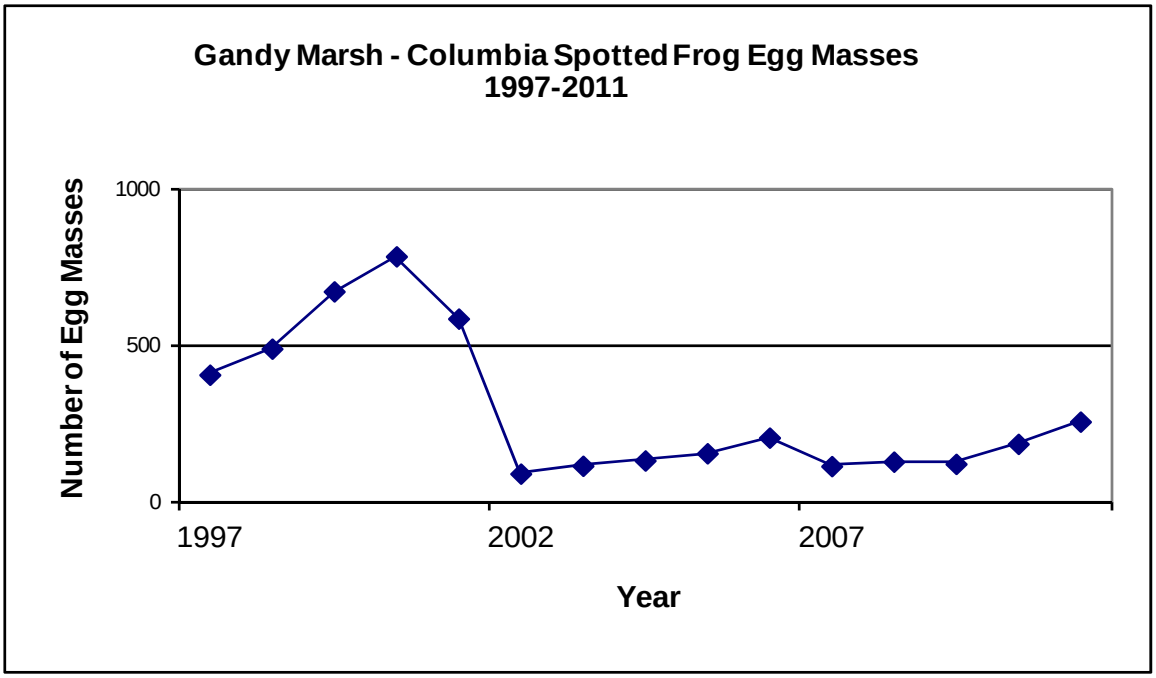

Figure 9. Number of Columbia spotted frog egg masses observed during annual monitoring from 1997 to 2011 at Gandy Marsh, Utah.

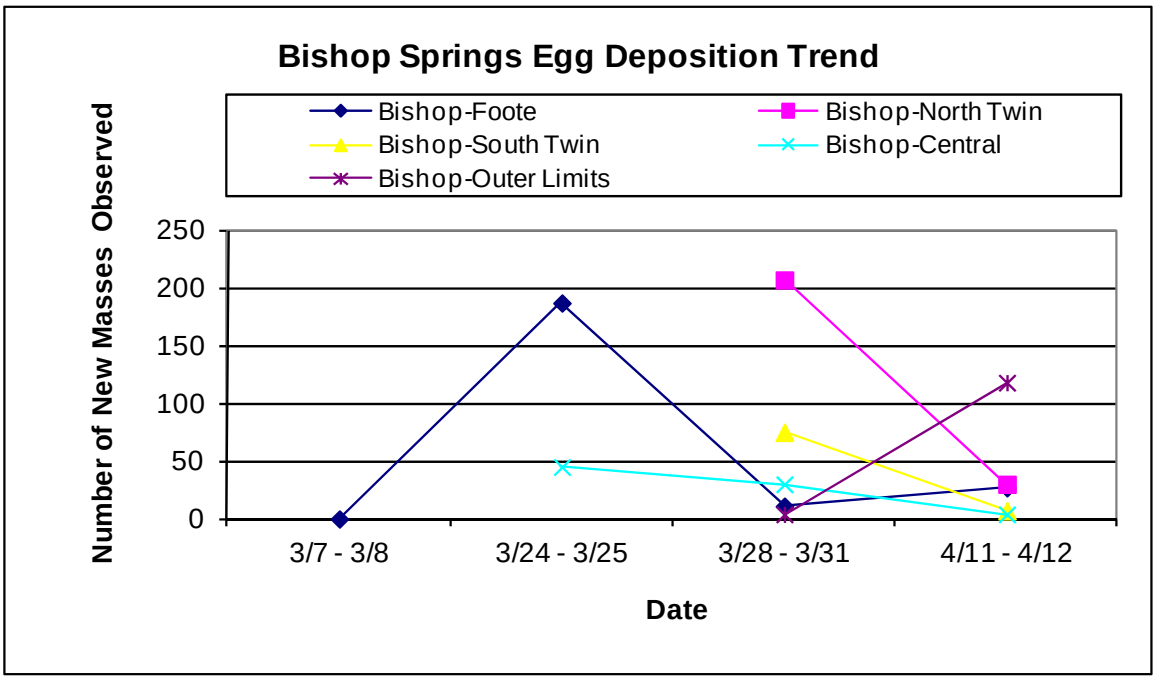

Figure 10. Columbia spotted frog egg mass deposition trend observed at Bishop Springs during spring 2011.

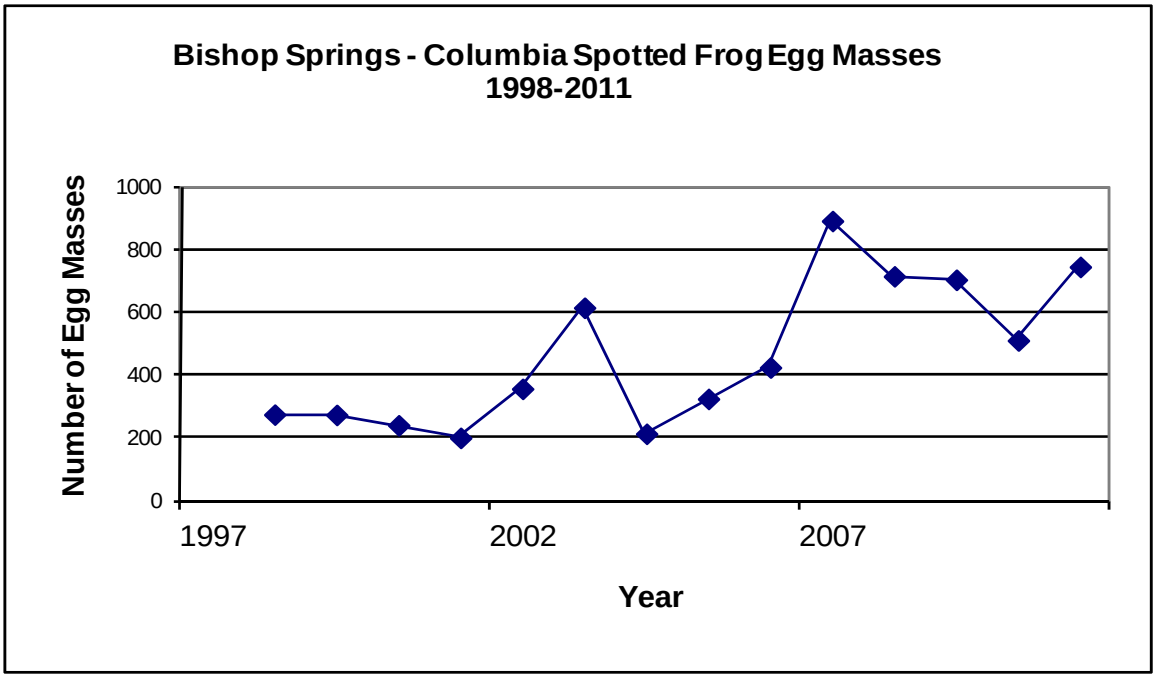

Figure 11. Number of Columbia spotted frog egg masses observed during annual monitoring from 1998 to 2011 at Bishop Springs, Utah.

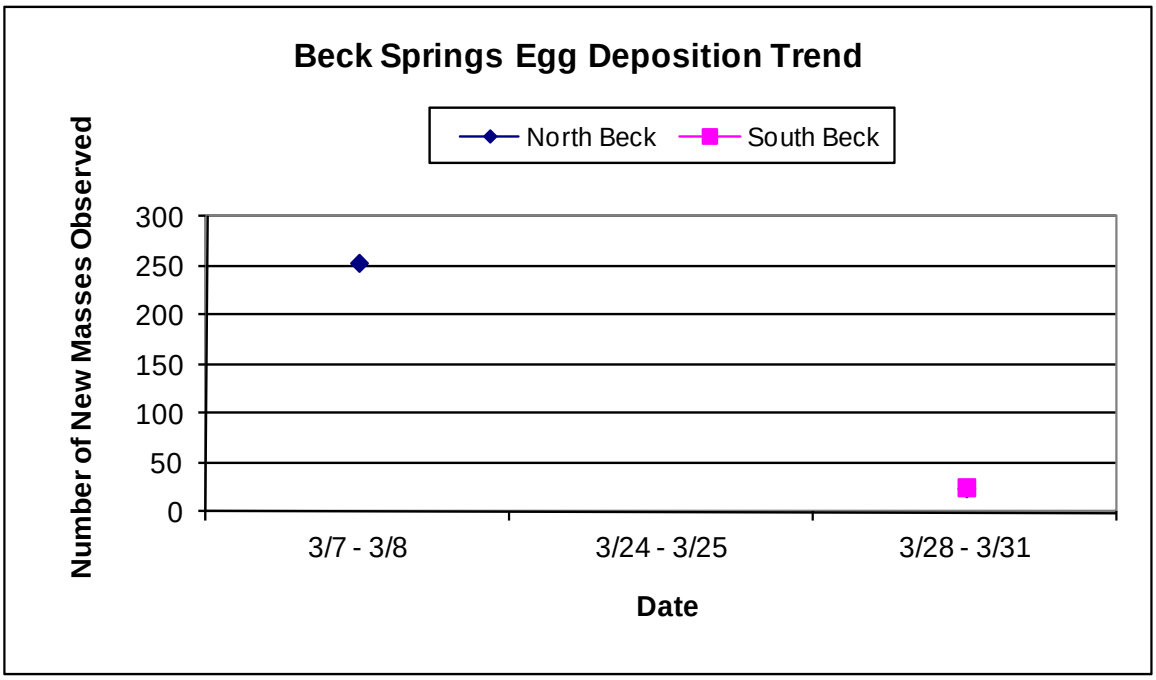

Figure 12. Columbia spotted frog egg mass deposition trend observed at Beck Springs during spring 2011.

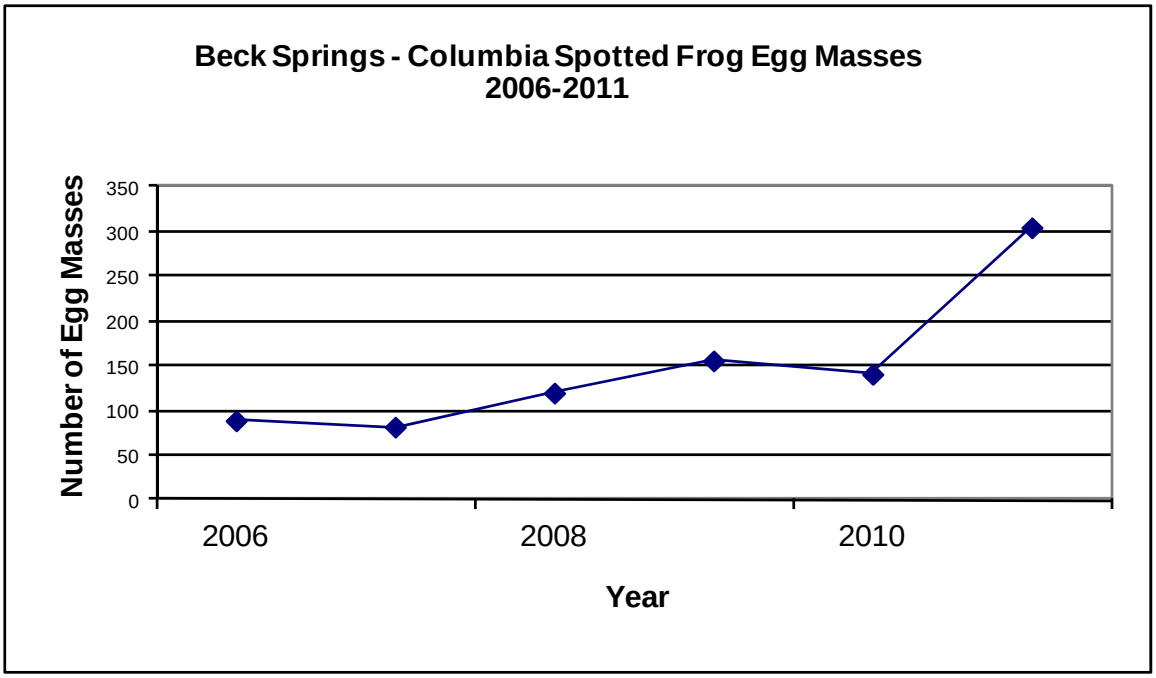

Figure 13. Number of Columbia spotted frog egg masses observed during annual monitoring from 2006 to 2011 at Beck Springs, Utah.

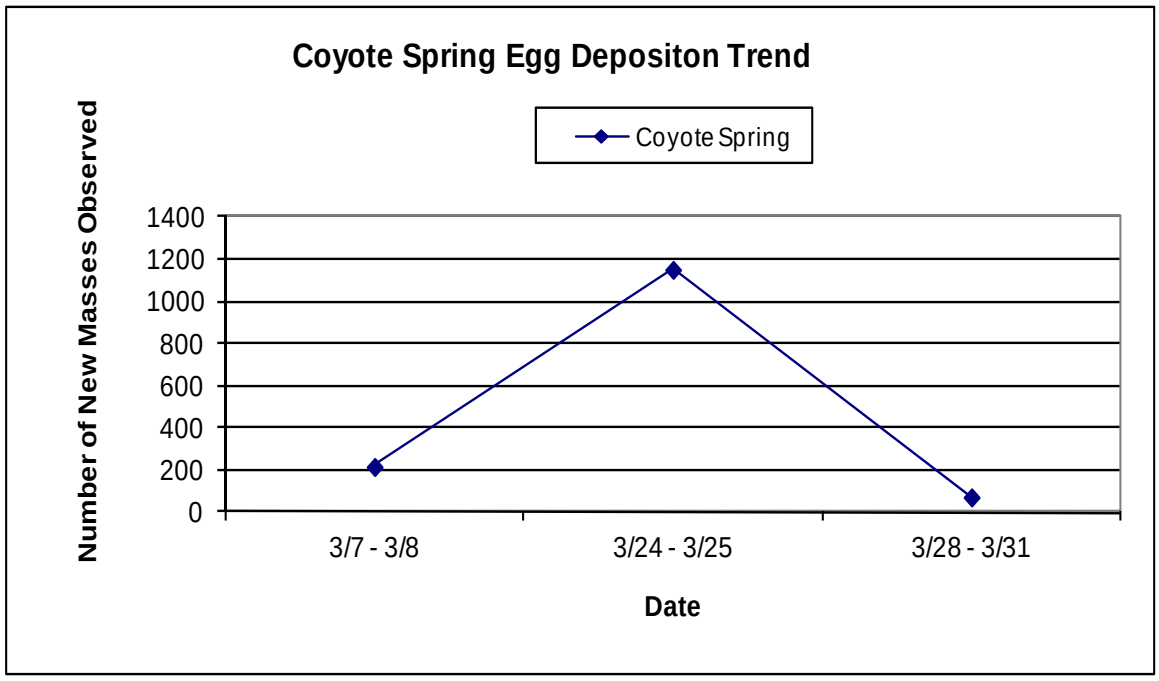

Figure 14. Columbia spotted frog egg mass deposition trend observed at Coyote Spring during spring 2011.

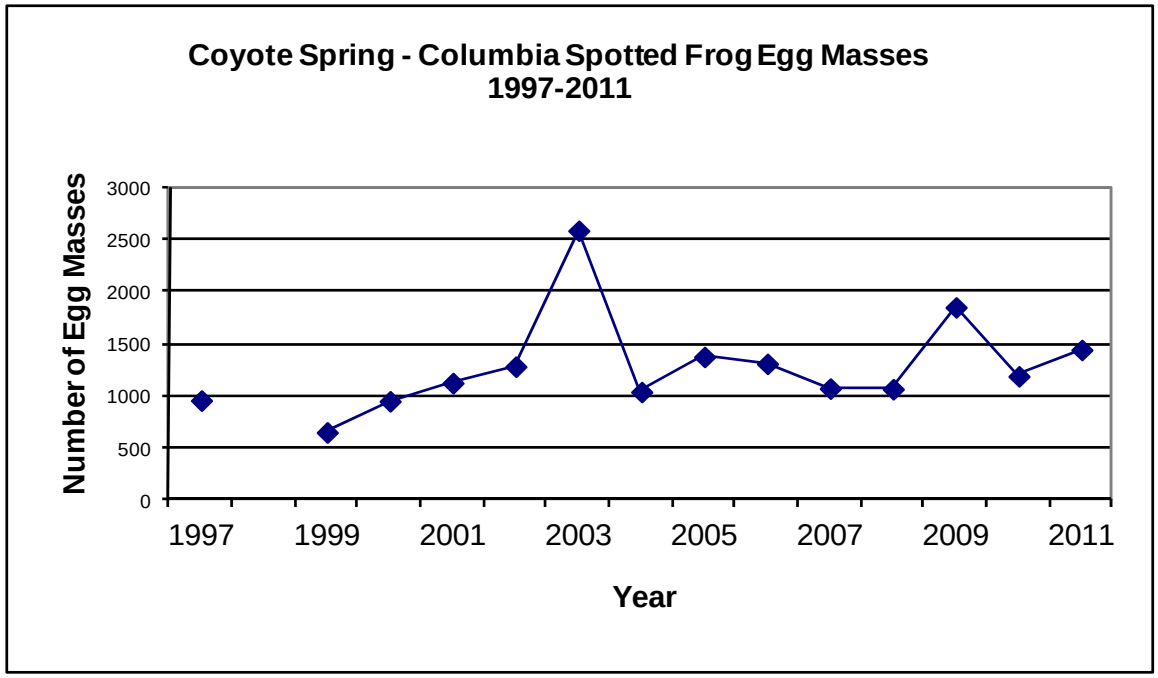

Figure 15. Number of Columbia spotted frog egg masses observed during annual monitoring from 1997 to 2011 at Coyote Spring, Utah.

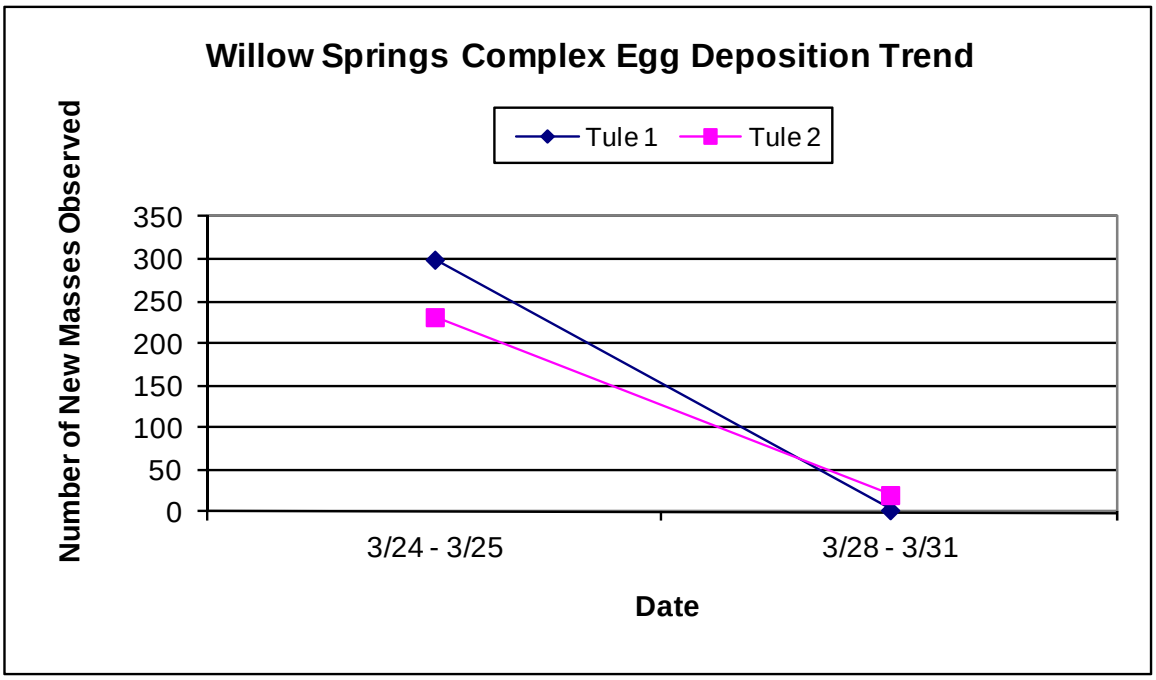

Figure 16. Columbia spotted frog egg mass deposition trend observed at the Willow Springs Complex during spring 2011.

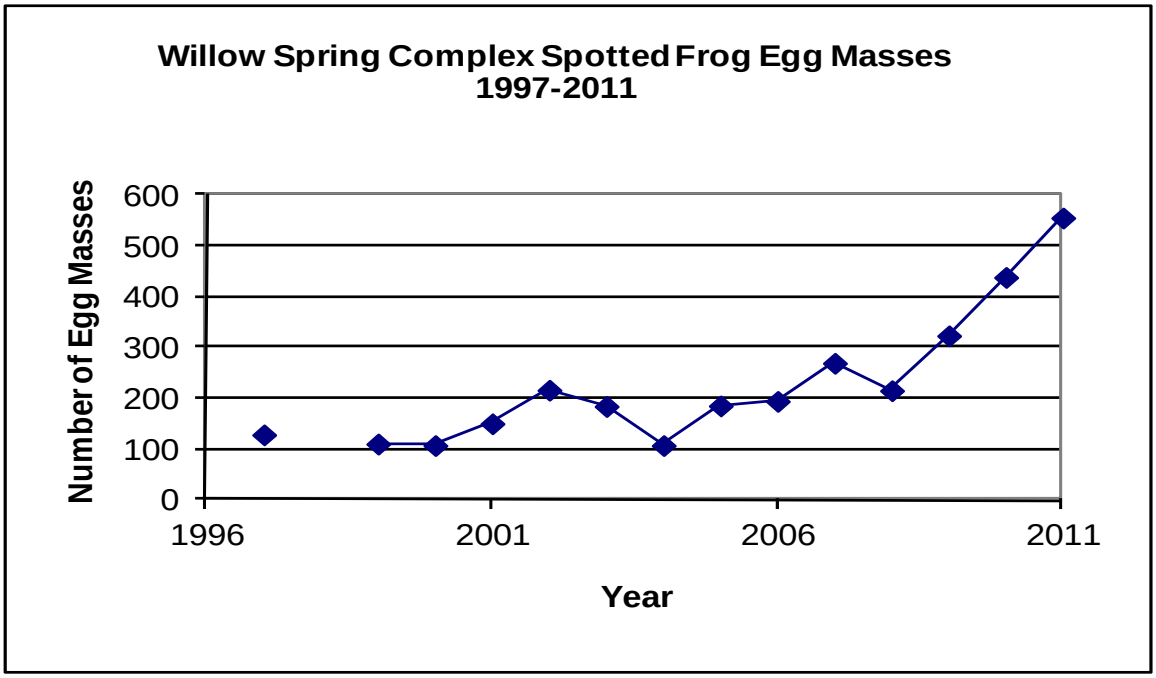

Figure 17. Number of Columbia spotted frog egg masses observed during annual monitoring from 1997 to 2011 at the Willow Springs Complex, Utah.

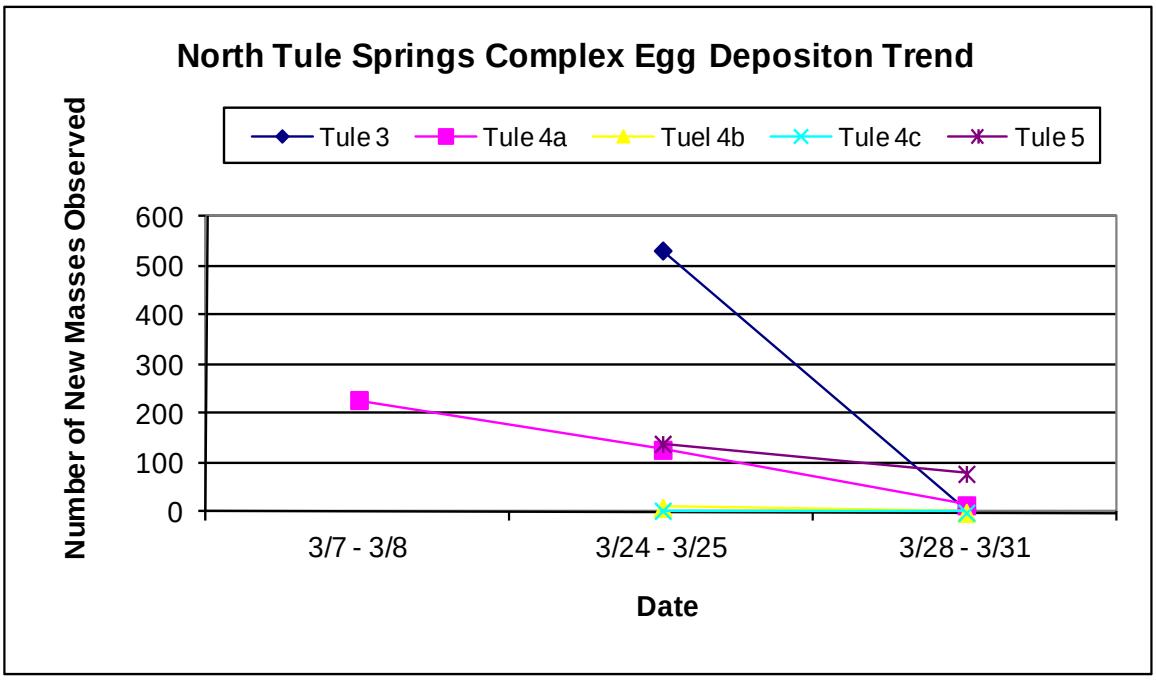

Figure 18. Columbia spotted frog egg mass deposition trend observed at the North Tule Springs Complex during spring 2011.

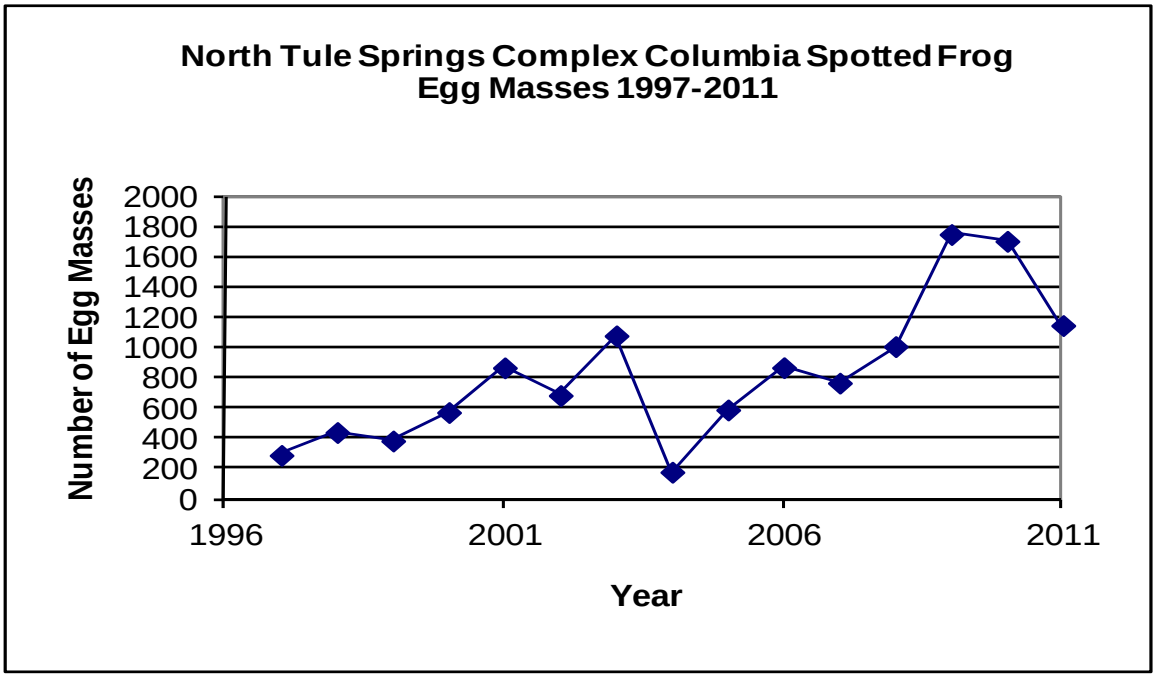

Figure 19. Number of Columbia spotted frog egg masses observed during annual monitoring from 1997 to 2011 at the North Tule Springs Complex, Utah.

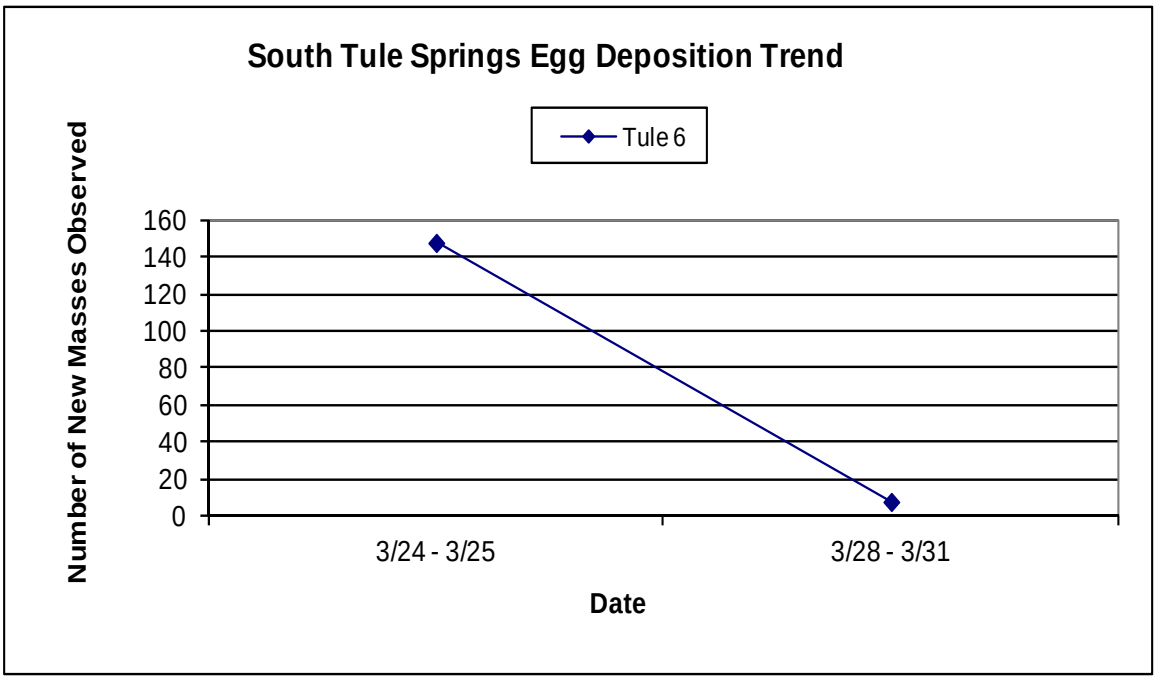

Figure 20. Columbia spotted frog egg mass deposition trend observed at the South Tule Springs during spring 2011.

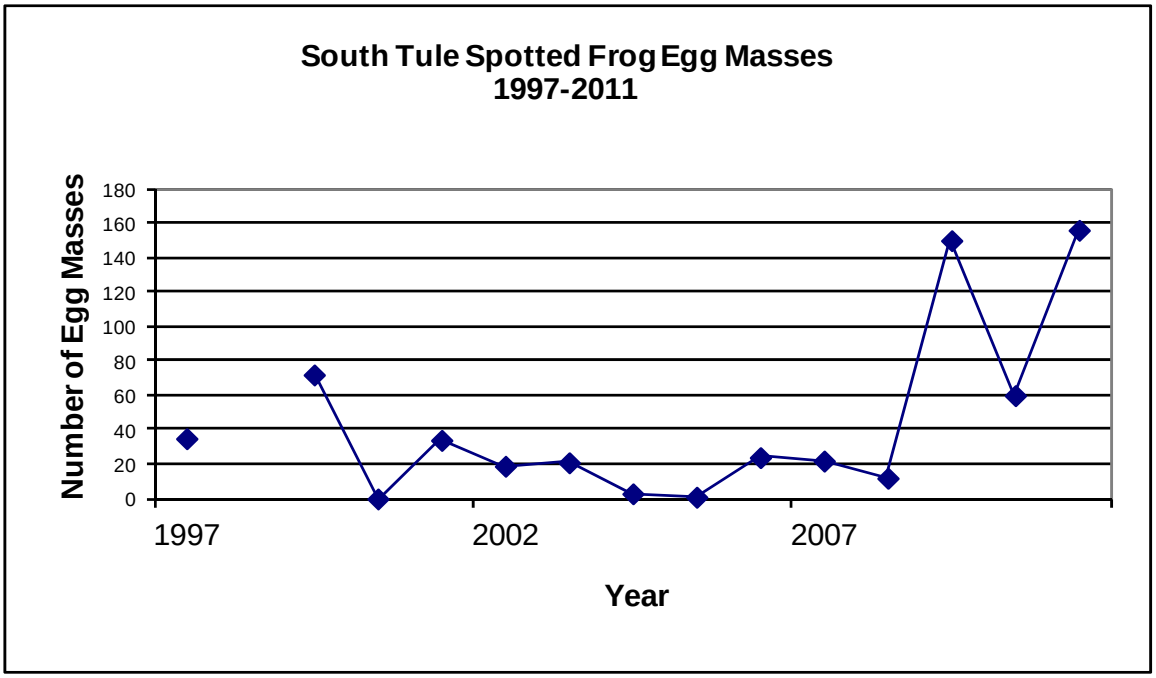

Figure 21. Number of Columbia spotted frog egg masses observed during annual monitoring from 1997 to 2011 at the South Tule Springs, Utah.